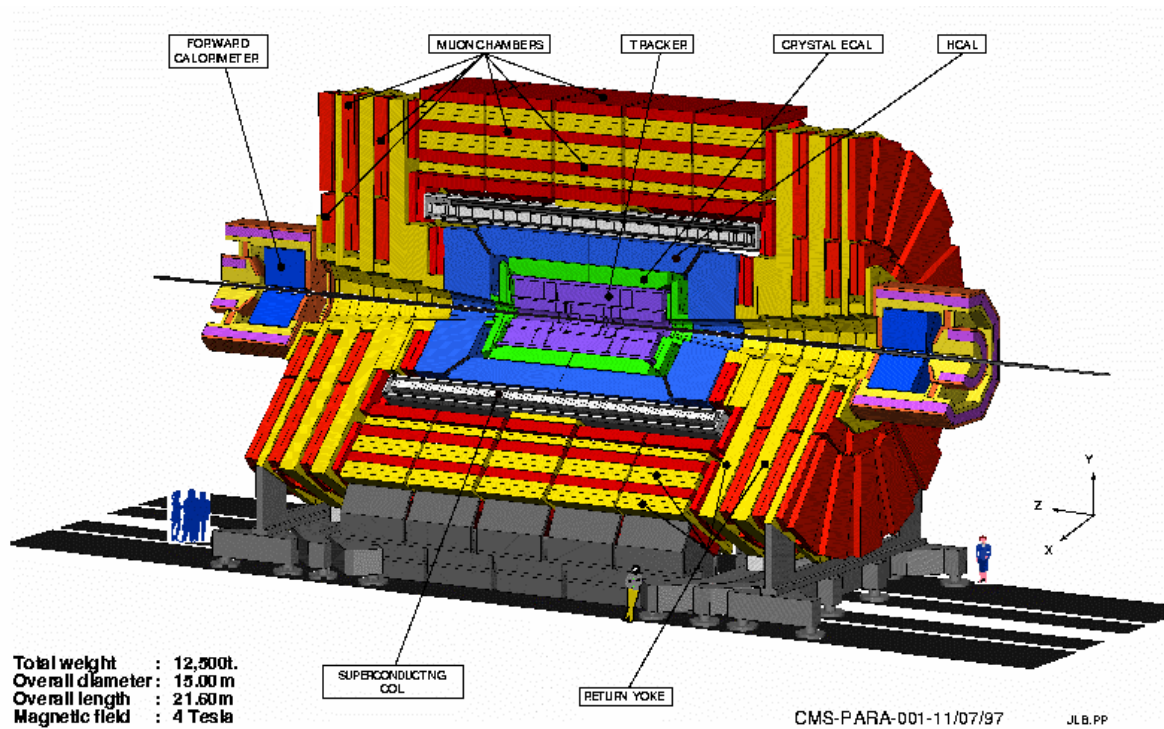


Appendix 2.C.

U.S. CMS Detector Construction Project Management Plan



US CMS PROJECT

PROJECT MANAGEMENT PLAN

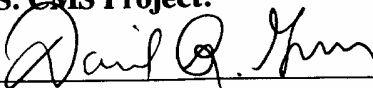
Revision 1.0 – December, 2002

Submission and Approvals

This Management Plan defines the plans, organization, systems and relevant interfaces for the U.S. CMS Collaboration's construction project for the CMS Detector as part of the Large Hadron Collider (LHC) at the European Laboratory for Nuclear Research (CERN). The U.S. role in the construction of the CMS detector is funded jointly by the U.S. Department of Energy and the National Science Foundation.

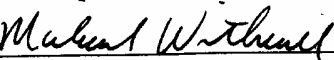
Submitted and Accepted by:

U.S. CMS Project:

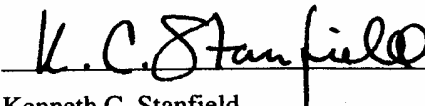


Daniel R. Green
U.S. CMS Project Manager

Fermilab:



Michael S. Witherell
Fermilab Director

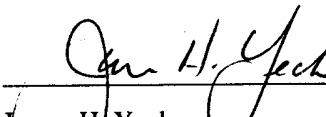


Kenneth C. Stanfield
Fermilab Deputy Director

DOE Fermi Area Office:

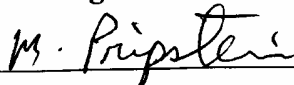


Jane L. Monhart
DOE Fermi Area Office Manager

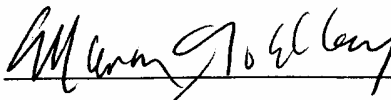


James H. Yeck
U.S. LHC Project Manager

LHC Program Office:



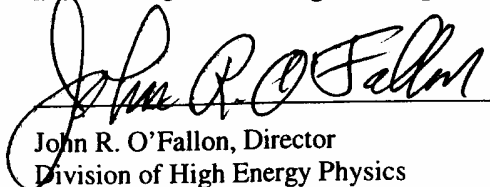
Moishe Pripstein, DOE
U.S. LHC Program Manager



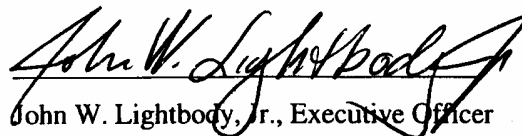
Marvin Goldberg, NSF
U.S. LHC Associate Program Manager

Approved by:

DOE/NSF Joint Oversight Group



John R. O'Fallon, Director
Division of High Energy Physics
U.S. Department of Energy



John W. Lightbody, Jr., Executive Officer
Physics Division
National Science Foundation

US CMS Project Management Plan (Revision 1.0)

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1. INTRODUCTION

1.1 OVERVIEW AND SCOPE OF THE U.S. CMS PROJECT MANAGEMENT PLAN

This document is the Project Management Plan (PMP) that the U.S. Compact Muon Solenoid (CMS) Collaboration will follow to meet the technical, cost, and schedule objectives of the U.S. CMS Project. It is consistent with the general management approach used to manage major U.S. Department of Energy (DOE) projects. This PMP covers the design, fabrication, construction, assembly, testing, delivery and installation of the U.S. deliverables/components to the CMS detector at CERN.

This PMP describes the management, organization, systems and procedures used to manage those aspects of the U.S. CMS Project that are internal to the U.S. CMS Collaboration. This includes control of budget, schedule and work within all U.S. CMS institutions, the management structure of the U.S. CMS Project, and the relationship between the DOE, NSF and the Host Laboratory, Fermilab.

This PMP establishes the technical, cost and schedule baseline to which the U.S. CMS Project will be managed and to which the performance of the project will be measured. The PMP defines the highest level Work Breakdown Structure (WBS) for the project and presents a corresponding organizational structure with responsibilities assigned to the major subsystems. Major schedule milestones are defined, along with the cost estimate of each major subsystem to support this schedule. This PMP also describes the project management control mechanisms, configuration and change management, reporting requirements, and contingency allocation procedures.

This PMP does not cover the Maintenance and Operations (M&O), activities for the CMS experiment of the delivered components at CERN, which are outside of the scope of the U.S. CMS Project. Additionally, this PMP does not include any effort related to the U.S. CMS Software & Computing (S&C) Project, a parallel U.S. CMS project whose mission is to develop the software and computing resources necessary to enable U.S. physicists to fully participate in the physics of CMS. It is anticipated that at the onset of CMS detector operations, U.S. CMS will merge M&O and S&C into a single, cohesive U.S. CMS Research Program, which will be a

subprogram of the U.S. LHC Research Program. Additional clarification on the defined boundaries between M&O and S&C can be found in the PMP glossary.

This PMP will be reviewed and revised, as required, to reflect new project developments or other agreements among the participants. Revisions will be endorsed by the U.S. CMS Project Manager, the Director and Deputy Director of Fermilab, U.S. LHC Project Manager, the Manager of the Fermi Area Office for the DOE Chicago Operations Office, the Program Manager and Associate Program Manager for the U.S. LHC Program, and jointly approved by the Director of the DOE Division of High Energy Physics and the Executive Officer of NSF Physics Division. To the extent that there are inconsistencies or conflicts between this plan and the terms and conditions of applicable laws, regulations, existing contracts, and relevant Memoranda of Agreement, or the Project Execution Plan for the U.S. Large Hadron Collider Projects, the provisions of those documents shall prevail over this plan.

1.2 REFERENCE DOCUMENTS

Additional documentation related to agreements that support the U.S. CMS Collaboration in its work on the CMS detector, are listed below. Copies of all of associated documents, including their most recent and applicable revisions, as consistent with the International Cooperation Agreement between CERN, DOE and NSF (December 1997), reside in the U.S. CMS Project Office at Fermilab.

1. General Conditions for Experiments Performed at CERN (April 1989) – Defines the roles and responsibilities of CERN, as the Host Laboratory, and the CMS Collaboration.
2. U.S. CMS Collaboration Letter of Intent (September 1995) – Proposal for U.S. participation in the construction of the CMS Detector.
3. CMS Constitution (September 1996) – Organization, structure, and management systems governing the CMS Collaboration.
4. International Cooperation Agreement between CERN, DOE and NSF (December 1997) – Defines the program of work, responsibilities and funding for the U.S. participation in the LHC.

5. MOU between U.S. CMS and U.S. Collaborating Institution (June 1998) – Defines the program of work, responsibilities and funding for the U.S. institution's participation in the U.S. CMS Project.
6. U.S. CMS Project Management Plan (June 1998) – Earlier version of the U.S. CMS Project Management Plan, now replaced by this revision.
7. The U.S. LHC Project Execution Plan (December 1998) – Mission need, scope and goals of U.S. participation in the LHC, and description of management and executive processes governing the U.S. LHC effort.
8. MOU between DOE and NSF concerning the LHC (December 1999) – Communication and coordination of funding agencies as it applies to U.S. participation in the LHC.
9. U.S. CMS Constitution (June 2000) – Organization, structure, and management systems governing the U.S. CMS Collaboration.
10. U.S. CMS Technical Baseline Document (October 2002) – Controlled document that describes the technical scope of the U.S. CMS Project.

1.3 LIST OF ABBREVIATIONS

Item	Definition
ACWP	Actual Cost for Work Performed
ALAP	As Late As Possible
APM-DD	Agency Project Manager-Fermilab Deputy Director
AY\$	Actual Year Dollars (Spent)
BAC	Budget at Completion
BCR	Baseline Change Request
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CB	CMS Collaboration Board
CSC's	Cathode Strip Chambers
CD	Critical Decision
CERN	European Organization for Nuclear Research
CH	DOE Chicago Operations Office
CV	Cost Variance
CMS	Compact Muon Solenoid
CP	Common Projects
CPR	Cost Performance Report
DAQ	Data Acquisition
DOE	United States Department of Energy
DOE-SC	U.S. DOE Office of Science
DPM	U.S. CMS Deputy Project Manager
ECAL	Electromagnetic Calorimeter
EDMS	Engineering Data Management System

<u>Item</u>	<u>Description</u>
EDR	Engineering Design Review
EMU	Endcap Muon
ES&H	Environment Safety and Health
GLIMOS	Group Leader in Matters of Safety
FAO	U.S. DOE Fermi Area Office
Fermilab	Fermi National Accelerator Laboratory
FNAL	Fermi National Accelerator Laboratory
FPIX	Forward Pixels
HCAL	Hadron Calorimeter
IB	U.S. CMS Collaboration Institutional Board
JOG	Joint Oversight Group
L2M	WBS Level 2 Manager
L3M	WBS Level 3 Manager
LHC	Large Hadron Collider
LHCC	CERN LHC Committee
m	Meters
M&O	Maintenance and Operations
MB	CMS Management Board
MCHF	Million Swiss Franc
MOU	Memorandum of Understanding
NSF	National Science Foundation
MPO	Memorandum Purchase Order
OER	DOE Office of Energy Research
PEP	U.S. LHC Project Execution Plan
PM	U.S. CMS Project Manager
PMG	Project Management Group
PMP	U.S. CMS Project Management Plan
PO	U.S. CMS Project Office
PRR	Production Readiness Review
QA	Quality Assurance
QAP	Quality Assurance Plan
R&D	Research and Development
RFP's/Q's	Request for Proposals/Quotations
RRB	CMS Resource Review Board
SC	Steering Committee
SC/CMD	Office of Science/Construction Management Division
S&C	Software and Computing
SiTrkr	Silicon Tracker
SOW	U.S. Institutional Statement of Work
SV	Schedule Variance
TEC	Total Estimated Cost
TIS	Technical Inspection & Safety
TPC	Total Project Cost
TRIG	Trigger
URA	Universities Research Association
UX	CMS Underground Experimental Cavern
WBS	Work Breakdown Structure

2. CMS DETECTOR OBJECTIVES

2.1 SCIENTIFIC OBJECTIVES

The Compact Muon Solenoid (CMS) Detector is a general purpose colliding beam detector designed to study proton on proton collisions with center of mass energy of 14TeV and luminosity of $10^{34}\text{cm}^{-2}\text{s}^{-1}$ at the Large Hadron Collider (LHC) located at the European Laboratory for Nuclear Research (CERN) near Geneva, Switzerland. CMS is expected to operate at the LHC for twenty or more years, observing collisions of protons, and with appropriate upgrades, is expected to record more than 10^9 events per year.

The critical scientific objectives to achieve these goals are:

- Excellent muon identification capability and momentum resolution.
- Efficient tagging of b-decays and τ -jets.
- Excellent photon and electron identification capability, as well as energy and directional resolution.
- Hermetic calorimetry coverage to allow accurate measurement of direction and magnitude of energy flow, and excellent reconstruction of missing transverse momentum.
- Efficient charged particle track reconstruction and good momentum resolution.
- Well-understood trigger and data acquisition systems to go from 1 GHz raw interaction rate to ~ 100 Hz readout rate without significant loss of interesting signals.

2.2 TECHNICAL OBJECTIVES

The overall dimensions of the CMS detector are immense, with a length of 21.6m (HCAL Forward Calorimeters excluded), a diameter of 15.0m, and a total weight of 12500 tonnes. Its central feature is a high field (4 Tesla) solenoid of 13m in length and a 2.95m radius. CMS will be one of the most complex scientific instruments ever built.

The U.S. CMS Collaboration has agreed to assume responsibility for the U.S. CMS Project with a Total Project Cost (TPC) of \$167.25M actual-year dollars (AY\$), which includes a defined set of deliverables, along with leadership responsibilities in the CMS experiment for the Endcap Muon System, Hadron Calorimetry, as well as for associated aspects of the Trigger

and Data Acquisition subsystems. The U.S. CMS Collaboration has also taken responsibility for important areas of Electromagnetic Calorimetry, Central Tracking (both pixels and barrel), and Common Projects. The Common Projects contribution to CMS is agreed to not exceed \$23M AY. Complete details on U.S. commitments to CMS are defined in the U.S. CMS Technical Baseline Document [Ref. 10], copies of which are available in the U.S. CMS Project Office at Fermilab.

For all subsystems, the U.S. strategy has been to assume responsibility for deliverables that focus on a particular area of U.S. expertise. Furthermore, U.S. CMS has attempted to assume responsibilities for major deliverables along with its subparts, providing an opportunity for vertical integration and allowing some autonomy in optimizing resources and schedule for production of U.S. deliverables.

2.3 COST OBJECTIVES

The U.S. CMS Collaboration has taken responsibility for roughly 20-25% of the CMS detector, with a Total Project Cost (TPC) of \$167.25M AY. Appendix 9 shows a U.S. CMS cost breakdown at the subsystem level. Using European costing methodologies, which largely ignore institutional labor costs, the overall cost of the CMS detector is currently estimated at 509.0 MCHF (Million Swiss Francs).

2.4 SCHEDULE OBJECTIVES

The U.S. CMS Construction Project was initiated with the U.S. CMS Collaboration's Letter of Intent in September 1996, with the cost, schedule, and technical baseline for the U.S. CMS Construction Project approved in May 1998. The baseline schedule called for the LHC machine to begin operations in July 2005 and the DOE/NSF Joint Oversight Group approved September 2005 as the U.S. project completion milestone, Critical Decision (CD) -4, for the U.S. CMS construction project.

In June 2002, CERN announced a schedule delay in the LHC Project that directly impacts CMS. In discussions with CERN, LHC and U.S. CMS management, CMS management has prepared a new baseline schedule (version 33), calling for first collisions at CMS in April 2007, with the first data run scheduled for August 2007. This schedule is consistent with the overall LHC and CMS planning.

The U.S. CMS strategy has been to assume responsibility of entire subsections of the CMS detector in order to decouple the U.S. effort from the CMS schedule as much as possible. However, certain U.S. commitments, such as installation tasks in the CMS underground cavern (UX) and some procurements scheduled As Late As Possible (ALAP) to take advantage of advancing technology will fall beyond the end of FY05. The impact on the original CD-4 date of September 30, 2005 is a direct consequence of delays at CERN and not the result of difficulties within the U.S CMS project.

To address this schedule impact on the U.S. CMS Project Complete, U.S. CMS has adopted a phased CD-4 in a manner consistent with the guidance provided in DOE Order 413.3, Program and Project Management for the Acquisition of Capital Assets. The revised definition of CD-4 includes a milestone CD-4A, completion of approximately ninety-seven percent of the scope of U.S. CMS deliverables by the end of FY 2005, as originally planned, and a milestone CD-4B, completion of the final three percent of the scope of U.S. deliverables by the end of FY 2008. The final three percent of activities includes deliverables with schedules that are dependent on the actual completion and start-up schedule for the LHC machine. Significant schedule risk remains in the global CMS and LHC schedules, making it necessary for U.S. CMS to remain vigilant in its efforts to mitigate risks to the U.S. CMS Project. At the completion of the CD-4B milestone, U.S. CMS management will prepare a project closeout report for the U.S. CMS Project.

Both the U.S. schedule and cost are, of course, dependent on the rate of funding from the DOE and NSF, which is shown in Appendix 10. Assumed rates of out-year escalation are shown in Appendix 11. The U.S. CMS pre-operations and operations effort, which provides the necessary support to sustain and operate U.S. deliverables on the CMS detector once installed, will be supported by the M&O budget, and which began in 2002, and is thought to ramp up to its full commitment in 2006.

3 OVERALL CMS ORGANIZATION

The overall responsibility for the construction of the CMS detector resides with the CMS Collaboration, consisting of over 1800 physicists and engineers from 31 countries and 150 institutions. The U.S. CMS Collaboration, is part of the CMS Collaboration, and presently consists of 380 scientists and engineers from 38 U.S. universities and one national laboratory, as shown in Appendix 1.

The U.S. CMS Construction Project operates within the context of the internationally funded CMS experiment located at CERN. The general responsibilities of the U.S. participants, and CERN as the Host Laboratory for the CMS experiment are described in the Experiments Protocol signed between CERN, DOE and NSF [Ref.1].

3.1 THE INTERNATIONAL CMS PROJECT AND ITS MANAGEMENT

The CMS detector ranks among the most ambitious and challenging technical experiments ever proposed by the scientific community. The inter-regional collaborations assembled to design, implement, install and test the CMS detector face unprecedented sociological challenges in effectively marshaling their enormous human and economic resources. The overall CMS approach to this challenge is to base most of the CMS governance on the collaborating institutions rather than on national blocks. The organization of the full CMS Collaboration is described in the CMS Constitution of December 11, 1998, and is shown hierarchically in Appendix 2.

CERN management has the ultimate responsibility for CMS, and CMS reports to it. The Resource Review Board (RRB), with representatives from the constituent funding agencies, acts as an oversight board and liaison to CERN management to ensure that the CMS detector has sufficient resources to proceed on cost and schedule.

Within CMS, the principal organizational entity is the Collaboration Board (CB), consisting of one voting representative from each collaborating institution, regardless of size or national origin. The CB is the governing body of the CMS experiment and must ratify all policy and technical decisions, and all official appointments to official CMS positions. The

Chairperson of the CB is elected by the members of the CB and, along with the Deputy Chairperson, serves a renewable three-year term.

The executive function in CMS is provided by the CMS Management Board (MB). The MB is advised on technical matters by the Technical Board, and on financial matters by the Finance Board. All important matters of a scientific, technical, organizational and/or financial nature are discussed in the Management Board, which is chaired by the CMS Spokesperson. The Spokesperson is elected by the members of the CB and, along with the Deputy Spokesperson, serves a renewable three-year term. The nomination of the Deputy Spokesperson must be endorsed by the MB and the CB. In most cases, issues that require the deliberation and/or ratification of the CB are submitted by the MB.

The MB, through the Spokesperson, is responsible for directing the CMS project and for formulating policy. The MB, again through the Spokesperson, also represents the Collaboration in dealing with other CMS bodies such as the Finance Board and the Technical Coordination Group, and organizations and committees outside of CMS. The MB interacts, in particular, with the CERN Management and its various scientific committees.

A subset of the MB is the CMS Steering Committee (SC). The CMS Steering Committee supervises and reviews the progress and planning of the CMS Detector Project. The SC provides assistance and guidance to the Spokesperson, and its task is to optimize the resources available to the collaboration to achieve the best possible detector is built to address the physics of the LHC. As noted in Appendix 3, the U.S. has strong representation within the CMS MB and SC structures.

4. MANAGEMENT ORGANIZATION AND RESPONSIBILITIES

The U.S. CMS Detector Project is a subproject of the overall CMS Detector Project. Similarly, the U.S. CMS Collaboration is a subset of the CMS Collaboration consisting of over 380 scientists and engineers from 38 universities and one national laboratory. Successful construction of the CMS detector will enable U.S. high-energy physicists to participate in research at the physics frontier of the LHC. Related objectives of the U.S. CMS Project are to present significant opportunities for the U.S. CMS institutions to maintain their understanding of state of the art technologies related to high-energy physics research, and also to advance international cooperation in the construction of large science projects.

The U.S. CMS Project is described in the U.S. CMS Letter of Intent of September 8, 1995 and in the U.S. CMS Project Status Report of September 15, 1996. U.S. responsibilities within CMS include both management and construction.

Within CMS, the U.S. CMS Collaboration acts congruently with its governance described in “The U.S. CMS Constitution,” June 5, 2000. Elected representatives of the U.S. CMS Collaboration include a Collaboration Board Chair, Deputy Collaboration Board Chair and a U.S. CMS Advisory Board. U.S. CMS is financially responsible ultimately to DOE and NSF, which are, in turn, responsible to the U.S. Congress.

4.1 PROJECT OVERSIGHT ORGANIZATION STRUCTURE

4.1.1 U.S. Department of Energy (DOE) and National Science Foundation (NSF)

The DOE and NSF have jointly negotiated and signed an agreement and protocols with CERN for U.S. participation in construction of the LHC accelerator and in the international collaborations for construction of the ATLAS (A Toroidal LHC ApparatuS) and CMS detectors that will carry out the LHC scientific program. In accordance with the agreement and protocols, DOE is solely responsible for providing funding of \$200 million for goods and services for the LHC accelerator construction. In addition, DOE and NSF are responsible for providing funding of \$331 million, \$250 million and \$81 million, respectively, for goods and services toward the fabrication of the ATLAS and CMS detectors. Of this funding, the U.S. ATLAS Total Project Costs (TPC) is approved for \$163.75 million, with a TPC of \$167.25 million for CMS.

General program oversight for the U.S. CMS Project is the responsibility of the U.S. Department of Energy (DOE) and the National Science Foundation (NSF). As both DOE and NSF fund U.S. CMS, a Joint Oversight Group (JOG) has been formed to coordinate and communicate program oversight and perform periodic assessments on the performance of the U.S. CMS Project. DOE and NSF have requested, via the JOG, that the Fermi National Accelerator Laboratory (Fermilab), in Batavia, Illinois act as the Host Laboratory and assume management responsibilities for the U.S. CMS Project. Fermilab is a DOE Laboratory operated under contract DE-AC02-76-CH-03000 by Universities Research Association, Inc. (URA). The U.S. CMS Project Manager is a Fermilab employee. Appendix 4 provides an overall depiction of the oversight function.

The DOE has delegated responsibility for the U.S. CMS Project to the Office of Science, Division of High Energy Physics. The NSF has delegated responsibility for the U.S. CMS Project to the Division of Physics. The assigned divisions in DOE and NSF function together through the JOG. The activities of the JOG are carried out under the provisions of an International Cooperation Agreement between CERN, DOE and NSF signed on December 19, 1997 [Ref. 4].

4.1.2 Joint Oversight Group (JOG)

The Joint Oversight Group will establish programmatic guidance and direction for the U.S. CMS Project, coordinate DOE and NSF policy and procedures as it applies to the U.S. CMS, and oversee the project as described in the DOE/NSF Memorandum of Understanding (MOU) and the U.S. LHC Project Execution Plan.

The JOG is co-chaired by the Director of the DOE Division of High Energy Physics and the Director of the NSF Physics Division. The co-chairs of the JOG are ex-officio members of the RRB. Additional membership in the JOG is by the mutual agreement of the co-chairs. All documents approved by JOG are subject to the rules and practices of each agency and the signed agreements and protocols.

4.1.3 U.S. LHC Program Office

The U.S. LHC Program Office, led by the U.S. LHC Program Manager, will provide day-to-day program management and support for the U.S. participation in the LHC. The U.S. LHC

Program Office receives direction from and directly reports to the JOG. As the DOE has been designated “lead agency” for the U.S. LHC Construction Program, the LHC program manager will generally be a DOE employee appointed by the Director of the DOE High Energy Physics Division, subject to the concurrence of the JOG. The U.S. LHC Associate Program Manager will generally be an NSF employee appointed by the Director of the NSF Physics Division subject to the concurrence of the JOG. The Program Manager and Associate Program Manager are responsible for daily coordination of the joint oversight activities described in the MOU between DOE and NSF. Specific responsibilities of the U.S. LHC Program Office are defined in the U.S. LHC Project Execution Plan.

4.1.4 DOE Fermi Area Office

The DOE Fermi Area Office (FAO) has contract responsibility for Fermilab and provides day-to-day DOE oversight of Fermilab. FAO receives management and other support from the DOE Chicago Operations Office. The FAO will be the administrative home of the U.S. LHC Project Manager. The FAO Manager will delegate to the LHC Project Manager the authority for day-to-day implementation and direction of the project. The FAO Manager will also provide FAO staff support when necessary and appropriate.

4.1.5 U.S. LHC Project Office

The U.S. LHC Project Office, led by the U.S. LHC Project Manager, will provide day-to-day DOE/NSF project management and support for the U.S. LHC projects. The U.S. LHC Project Office serves as the day-to-day contact for DOE and NSF on issues specific to each of the U.S. LHC Projects. The U.S. LHC Project Manager will be appointed by the FAO Manager, subject to the approval of the JOG. Specific responsibilities of the U.S. LHC Project Office include:

- a) Review and recommend approval of project planning documents including the U.S. LHC Project Execution Plan and its attendant project management plan for the U.S. CMS project;
- b) Review and recommend approval of project baselines and evaluate project performance against such baselines;

- c) Implement procedures for baseline management and control and approve changes to the baseline at Level 2 of the Work Breakdown Structure and recommend changes or corrective action to Level 1 baseline;
- d) Conduct regular reviews of the U.S. CMS project and participate in collaboration reviews as appropriate;
- e) Participate and provide support for the U.S. LHC Program Office peer reviews and reviews by oversight committees;
- f) Maintain close contact with participating universities and Fermilab to assist in expediting the activities of the U.S. CMS project;
- g) Ensure compliance by U.S. CMS with DOE, NSF and CERN requirements as appropriate, e.g., ES&H and contracting regulations;
- h) Identify and arbitrate unresolved issues within the U.S. CMS Project and/or collaboration;
- i) Prepare quarterly reports and such other reports on the status of the U.S. LHC projects for DOE and NSF management as required in the Project Execution Plan and applicable DOE and NSF requirements;
- j) Manage all of the U.S. LHC Project Office documentation;
- k) Keep DOE and NSF management informed on significant project issues and events in a timely manner;
- l) Provide assistance and coordination on the planning for the U.S. LHC Research Program.

4.1.6 Host Laboratory (Fermilab) Organization

The DOE and NSF have jointly assigned management oversight for the U.S. CMS Project to the Fermi National Accelerator Laboratory (Fermilab), in Batavia, Illinois. Fermilab is a DOE Laboratory operated under contract DE-AC02-76-CH-03000 by Universities Research Association, Inc. (URA). A U.S. CMS Project Office has been formed, with its principal office sited at Fermilab, and has been charged with meeting the technical, cost, and schedule objectives of the U.S. CMS Project. As host laboratory to the U.S. CMS Project, Fermilab will serve as the location for most project reviews.

The use of Fermilab facilities and services shall be agreed upon via MOU with the U.S. CMS Collaboration as with the use of assets at any U.S. CMS institution. The use of these resources

will follow procedures consistent with the Fermilab's current policies. To the extent agreed by the Fermilab and the U.S. CMS Collaboration, the U.S. CMS Project will obtain indirect support from the Laboratory's support departments, which may include:

- Accounting and Budgeting
- Environment, Safety and Health
- Human Resources
- Legal
- Facilities Management
- Quality Assurance
- Information and Business Services

All support functions will be provided through Fermilab's organizational lines of authority and responsibility. U.S. CMS will direct questions of priority needs for support through normal lines of authority within Fermilab.

The services may include services provided to the Fermilab's U.S. CMS group or may be services provided to other U.S. CMS institutions. Within the framework of the MOU, specific items shall be negotiated annually by Fermilab (as host laboratory) by the U.S. CMS Project Manager and by the collaborating U.S. CMS institutions. Any specific items will have the commitments and the associated estimated costs described in the annual Statement of Work (SOW).

It is recognized that all entities, DOE, NSF, Fermilab, and the U.S. CMS Collaboration, will work as a team to accomplish the U.S. CMS Project.

4.1.7 Fermilab Director

The Fermilab Director has management oversight responsibility to ensure that the detector effort is soundly managed, that technical progress proceeds in a timely way, that technical and financial problems are identified and properly addressed, and that an adequate management organization is in place and functioning. Specific responsibilities of the Fermilab Director are:

- a) Appoint, on recommendation from the U.S. CMS Collaboration, the U.S. CMS Project Manager, subject to the concurrence of the Joint Oversight Group;
- b) Establish an advisory structure external to the U.S. CMS project for the purpose of monitoring both management and technical progress for all U.S. CMS activities;
- c) Ensure that the U.S. CMS Project Manager has adequate staff and support, and that the U.S. CMS management systems at Fermilab are matched to the needs of the project;
- d) Consult regularly with the U.S. CMS Project Manager to ensure timely resolution of management challenges;
- e) Review and concur on the international Memoranda of Understanding with CERN that specifies U.S. CMS project deliverables funded by DOE and NSF;
- f) Review and concur with the institutional Memoranda of Understanding for the U.S. CMS collaborating institutions that specify the deliverables to be provided and the resources available at each institution;
- g) Ensure that accurate and complete project reporting to DOE and NSF is provided in a timely manner, and;
- h) Review and approve baseline changes as prescribed in this document (the U.S. CMS PMP).

The responsibilities of Fermilab Director are further described in a letter of joint appointment from DOE and NSF to the Fermilab director, dated November 30, 1997. The Fermilab Director may delegate certain responsibilities and authorities to a duly appointed Fermilab staff member. The Fermilab Director has delegated certain responsibilities and authorities to the Fermilab Deputy Director.

4.1.8 Fermilab Deputy Director

The Fermilab Deputy Director is responsible for management oversight of the U.S. CMS project upon delegation from the Fermilab Director. The U.S. CMS Project Manager reports to the Fermilab Deputy Director and he/she will ensure that their duties are carried out effectively. The Fermilab Deputy Director concurs in the Memorandum of Understanding between CERN and U.S. CMS and in the Memoranda of Understanding and Statements of Work between U.S. CMS and the collaborating institutions. In addition, the Project Management Plan, cost estimate,

schedule, and financial plan for the U.S. CMS project, all require the approval of the Fermilab Deputy Director and DOE and NSF with the concurrence of CMS and CERN.

4.1.9 Project Management Group

To exercise management oversight for the U.S. CMS Project, a Project Management Group (PMG) will be organized and convened by Fermilab. The Deputy Director chairs the PMG, and will prepare the agenda as necessary to adequately monitor the progress of the U.S. CMS project. The PMG will include members from Fermilab, U.S. CMS, and can be observed by the U.S. LHC Project Manager. The U.S. CMS Collaboration Board Chair is also a member of the PMG, thus ensuring communication of scientific issues to the U.S. CMS Collaboration.

The PMG also serves as a Level 2/Level 3 Change Control Board for approving changes requests to the project baseline (see Appendix 10 for Change Control thresholds). The PMG receives and reviews the monthly performance reports of the U.S. CMS Project.

The PMG will meet regularly, as deemed necessary by the Fermilab Deputy Director, in order to provide routine interactions with the U.S. CMS project management. The PMG will identify actions and initiatives to be undertaken to achieve the goals of the project including the allocation of both financial and human resources. If necessary, the PMG may be used as a review board to assess critical areas of the U.S. CMS project.

4.2. U.S. CMS PROJECT ORGANIZATIONAL STRUCTURE

4.2.1 General Management Structure

To facilitate interactions with the U.S. funding agencies and for effective management of U.S. CMS activities and resources, a U.S. CMS Project Office (PO) has been established at the host laboratory, Fermilab. Appendix 5 shows the management structure of the U.S. CMS Project. The U.S. CMS Project Manager (PM) has overall responsibility to provide programmatic coordination and management for the work performed at the participating institutions and to meet the objectives of the U.S. CMS Project. U.S. Level 2 Managers are appointed for each of the major detector subsystems in which the U.S. is involved. U.S. Level 2 managers appoint U.S. Level 3 Managers should the size and complexity of a certain subsystem

warrant another level of management. The organization also includes an Institutional Board (IB) with representation from each collaborating institution, and a U.S. CMS Advisory Board.

U.S. CMS planning and management are conducted in close communication and cooperation with overall CMS management. The U.S. L2 Managers interact closely with the corresponding CMS Subsystem Project Managers, and the U.S. CMS Project Manager maintains close contact with the CMS Spokesperson and the CMS Technical and Resource Coordinators.

The PM annually determines the allocation of funds to U.S. CMS institutions based upon the detailed planning models of the Level 2 Subsystem Managers in light of available funding as provided by the DOE and NSF. Each Level 2 planning model captures all U.S. CMS commitments to the CMS detector and is consistent with the approved global CMS schedule. Commitments of each institution to the U.S. CMS Project are explicit as defined in each U.S. CMS Memoranda of Understanding and the subsequent annual Statements of Work (SOW). Subcontracts, e.g. Memorandum Purchase Orders (MPO's) are issued to those institutions (including Fermilab as a U.S. CMS collaborating institution), which are in agreement with their respective SOW. An overview of the MOU, SOW, and funding and reporting process is described in Appendix 6.

4.2.2 The U.S. CMS Project Manager

The U.S. CMS Project Manager (PM) has overall responsibility to provide coordination and management for the U.S. CMS Project. He/she represents the U.S. CMS Project in interactions with CMS management, CERN, DOE, NSF, Fermilab and the U.S. collaborating universities. The PM is appointed by the Director of Fermilab and with concurrence of the DOE and NSF upon recommendation from the U.S. CMS Collaboration. He/She reports to the Fermilab Director (or his/her appointed representative). Specific responsibilities of the PM include:

- a) Provide general administration, planning, organization and control on a day-to-day basis to complete the U.S. CMS Project on schedule and within the authorized budget;
- b) Appoint, after consultation with the Collaboration, the U.S. Subsystem Level 2 Managers (L2M's), who are responsible for coordination and management within each detector subsystem. The L2M's will serve with the PM's continuing concurrence;

- c) Prepare yearly funding requests to DOE and NSF for the anticipated U.S. CMS activities;
- d) Recommend to DOE and NSF, upon advice of the L2M's, the institution-by-institution funding allocations (SOW's), to support the U.S. CMS efforts;
- e) Approve, in consultation with the L2M's, budgets, fund management and contingency allocation in accordance with approved change control;
- f) Establish, with the support of Fermilab management, a U.S. CMS Project Office with appropriate support services;
- g) Establish, if necessary, and with the support of Fermilab management, advisory groups or other mechanisms that Fermilab management finds necessary to carry out its oversight responsibility;
- h) Maintain close communication with the Fermilab Director or his/her delegated representative on the progress of the U.S. CMS effort, and report promptly any problems that may benefit from the joint efforts of the PM and Fermilab management;
- i) Interact with CMS and CERN management on issues affecting resource allocation and availability;
- j) Advise DOE and NSF representatives at CMS Resource Review Board meetings;
- k) Negotiate and sign the U.S. Institutional MOUs representing agreements between the U.S. CMS Project and the U.S. CMS collaborating institutions specifying the deliverables to be provided and the resources available on an institution-by-institution basis;
- l) Publish a monthly report on the activities, issues, performance and fiscal status of the U.S. CMS Project;
- m) Make periodic reports to the JOG on the status and issues of the U.S. CMS Project;
- n) Make periodic reports to the U.S. CMS Institutional Board to ensure that the U.S. CMS Collaboration is fully informed about important issues;
- o) Ensure that all elements of the project conform to applicable U.S. and CERN ES&H and Quality Assurance requirements.

4.2.3 The U.S. CMS Project Office (PO)

The day-to-day control of the U.S. CMS Project will be performed by the U.S. CMS Project Office (PO) at Fermilab. This office consists of the Project Manager, Deputy Project Manager, Budget Officer, Resources Manager, and Administrative Support. In addition, the PO

includes administration functions at Northeastern University to facilitate and track NSF disbursements, and a “branch” at CERN will be set up to monitor U.S. activities at CERN and act as a liaison for U.S. visitors.

Project contingency funds are held in the U.S. CMS Project Office by the PM. Allocations of contingency funds will be transferred to individual U.S. CMS subsystems based upon Baseline Change Requests submitted by the respective L2 manager and approved by the PM using approved change control procedures.

The PO will maintain all official documentation for the Project and ensure that the U.S. CMS Collaboration and its sponsors, the DOE and NSF, are fully informed of the latest developments, action items, and/or changes that affect the U.S. CMS Project, the CMS Detector, or the overall LHC Project. The WBS Level 2 and Level 3 Managers report performance and status of their respective subsystem to the PO on a monthly basis.

4.2.3.1 Northeastern University Branch Project Office

The U.S. CMS Project Office includes a Northeastern University (NEU) Administrator of NSF Funds as indicated in Appendix 5. The Administrator of NSF Funds is responsible for administration, disbursement, and reporting on the use of NSF funds in accordance with the NSF cooperative agreement with NEU. The NSF Administrator is appointed by the NSF and serves as the NSF liaison on the CMS Finance Board. The NSF Administrator is a member of the Project Management Group.

As a member of the project management team, the NEU Administrator reports to the U.S. CMS PM and under his/her direction, arranges for the appropriate procurement instrument (e.g. Subcontract) to be issued from NEU to the respective U.S. CMS participating institutions. Disbursement and utilization of funds provided by the NSF for U.S. CMS are subject to this management plan and the configuration, change control, and reporting procedures herein defined. The annual Statement of Work (SOW) describes a work plan for each institution that is consistent with the scope of the U.S. CMS Project and approved by the DOE and NSF. Subcontracts issued by Northeastern will authorize expenditures at the lowest level of the WBS in a manner consistent with the approved SOW for each institution. The NSF funded institutions will invoice NEU by WBS activity. U.S. CMS PM approval is required before invoices are paid.

NEU will track and record all NSF funds disbursed on behalf of U.S. CMS and will report this information monthly to the U.S. CMS Project Office.

4.2.3.2 CERN Branch Project Office

A branch office of the U.S. CMS Project Office is located at CERN to facilitate activities of U.S. CMS and CERN, and to improve the coordination and communication between the CMS Collaboration and the U.S. CMS collaborating institutes. The duties and responsibilities for the CERN branch office include:

- a) Monitor activities on the U.S. CMS L2 Team Accounts. Team Accounts are used by U.S. groups to make purchases at CERN;
- b) Act as a liaison for U.S. CMS institutions on communications, computing and database support with CERN and CMS;
- c) Act as a liaison for U.S. CMS to CERN Accounting;
- d) Act as a liaison for U.S. visitors to CERN and CMS;
- e) Expedite travel, computing support and shipping requests from U.S. CMS collaborators at CERN.

4.2.4 U.S. CMS Deputy Project Manager

The U.S. CMS Deputy Project Manager (DPM) reports to the PM and represents the PM in all U.S. CMS Project functions when the PM is not available. In addition, the DPM's responsibilities include:

- a) Maintain the overall management coordination, integration, and planning for the U.S. CMS Project;
- b) Maintain and report progress on U.S. CMS milestones and preserve agreement with the approved CMS schedule;
- c) Implement and maintain the U.S. CMS Earned-Value and Project Change Control described in this PMP (Section 8).
- d) Act as a liaison with the Fermilab management on such U.S. CMS issues as Fermilab resources and infrastructure, performance milestones, departmental issues and self-assessments;

- e) Assist L2M's in preparing for Engineering Design Reviews (EDR's), Production Readiness Reviews (PRR's) to ensure that project organization, integration and interface issues are addressed;
- f) Assist L2M's in preparing Request for Proposals/Quotations (RFP's/Q's), and market surveys for large capital procurements;
- g) Chair, as necessary to approve major production efforts, U.S. CMS Project Office reviews of L2 subsystems, draft official reports on the proceedings, and ensure that appropriate follow-up action, if required, is taken;
- h) Assist and coordinate integration tasks with U.S. CMS and international CMS.
- i) Assist and coordinate safety issues with U.S. CMS, CMS and CERN in conjunction with the U.S. CMS PM.
- j) Assist and coordinate Quality Assurance (QA) procedures across the U.S. CMS Project in accordance with the overall CMS detector and in conjunction with the PM.

4.2.5 U.S. CMS Budget Officer

The U.S. CMS Budget Officer reports to the PM and is the primary office of communication between U.S. CMS and other financial offices of Fermilab and U.S. CMS collaborating universities. The U.S. CMS Budget Officer's responsibilities include:

- a) Provide monthly summaries of budgets, costs, and obligations for the U.S. CMS Project;
- b) Aid and coordinate the Fermilab Memorandum Purchase Orders (MPO's) and NEU Subcontracts such that they are consistent with the approved Level 2 project files at the lowest WBS;
- c) Ensure that the L2 Cost Performance Reports (CPR's) accurately report costs, obligations and budgets at the lowest WBS;
- d) Act as a liaison between the U.S. CMS Project and Fermilab's Business Services Section.
- e) Prepare all budget planning documents and financial reports;
- f) Run ad-hoc reports and queries as requested to determine status of requisitions, purchase orders, and procurements;
- g) Run ad-hoc reports and queries as necessary to track effort charged to the U.S. CMS project and bring to the attention of the U.S. CMS PM/DPM any discrepancies;

- h) Oversee all U.S. CMS procurements, including ProCard purchases, and provide gate-keeping oversight of the requisition process;
- i) Audit the U.S. CMS Project financial reports.

4.2.7 U.S. CMS Resource Manager

The U.S. CMS Resource Manager reports to the PM and is the primary office of communication between U.S. CMS on international financial matters related to the U.S. CMS Project. The U.S. CMS Resource Manager also include the following responsibilities:

- a) Act as a liaison between U.S. CMS and CMS Resource Management and CERN;
- b) Monitor all U.S. CMS Team Account activity at CERN and regularly report on the budgets, costs and obligations for each team account;
- c) Act as a liaison to the U.S. CMS Project Office at CERN, providing instruction on budgetary and cost reporting methodologies and formats;
- d) Maintain and oversee the U.S. CMS L1 commitments, funding and performance projections;
- e) Maintain and oversee the U.S. CMS Project website.

4.2.8 WBS Level 2 Managers

The WBS Level 2 Managers (L2M's) are appointed by the U.S. CMS Project Manager. The Level 2 Managers are members of the Project Management Group, and have specific responsibilities listed below:

- a) Plan and manage the design, construction, installation, and commissioning of the L2 subsystem projects such that it meets U.S. commitments to CMS in accordance with the approved CMS and U.S. CMS schedules and milestones.
- b) Monitor and regularly update the baseline work scope, cost and schedule to present the most current integrated work plan;
- c) Define and organize the WBS L2 subsystem work scope, costs, and schedule to effectively utilize and coordinate each institution's resources within the U.S. CMS Collaboration;
- d) Serve as the cost/schedule managers for all WBS elements in their subsystem;

- e) Determine/validate the L2 subsystem schedule progress and actual costs at the end of each month. Discrepancies are to be resolved through the U.S. CMS Budget Officer;
- f) Evaluate monthly and cumulative-to-date budgets, earned value, and actual costs as defined in the L2 CPR;
- g) Analyze each month the L2 CPR cost and schedule variances provided and take corrective actions to meet technical, cost, and schedule baselines of U.S. CMS.

4.2.9 Education Outreach

The U.S. CMS Project Office includes an education liaison function to promote the development of educational proposals of U.S. CMS and outreach efforts to communicate the high-energy physics research in general, and the benefits of CMS in particular, to the public at large. In support of these and other educational activities, the U.S. CMS Project Office provides funding for programmatic travel and for material and service supplies. A U.S. CMS Educational Outreach Coordinator has been named who is a member of the U.S. CMS Collaboration. The Education Outreach Coordinator works with personnel from other laboratories and institutions to maximize the effectiveness of the educational outreach program.

5. WORK PLANNING

5.1 WORK BREAKDOWN STRUCTURE

All work required for the successful completion of the U.S. CMS Project is contained in the approved L2 subsystem baseline project files and is organized according to a Work Breakdown Structure (WBS). Each L2 WBS completely defines each subsystem's approved scope, cost, schedule, and the necessary resources to provide its commitments to CMS, and is the basis for all planning strategies and cost/schedule performance measurements. Each L2 WBS is created using Microsoft Project software, which provides a WBS that can support cost estimates at the task/element level and allows tracking performance of the WBS over time. Appendix 7 depicts the Common Project Subsystem 'opened up' revealing each WBS, descriptions, costs, funding source, and responsible institution. The relationship between WBS tasks is captured in the Gantt chart.

The levels of the WBS reflect the logical breakdown of the work required to complete each subsystem of the U.S. CMS Project. Each lower level provides greater detail, and at the lowest WBS, each task/element has an assigned cost, manpower, and schedule which is the key element for planning and controlling cost and schedule and measuring progress. The WBS of each subsystem expands to a level (often down to Level 7 or below) sufficient to allow definition of individual tasks/elements for which cost can be reasonably estimated and tracked during the construction phase of U.S. CMS.

Each L2 WBS is "resource loaded" by attaching the resources necessary to complete each task or element over the time allotted. The estimated cost of each subsection can be seen at any level from the summary WBS over contributing lower levels. Budgets are then derived from these costs estimates setting aside the necessary financial resources for carrying out specific activities in a given period.

Additional back-up information on each L2 WBS task/element is described in the WBS Dictionary and/or in each subsystem's Basis of Estimate. The WBS Dictionary provides a brief description of each WBS task, whereas the Basis of Estimate consists of the necessary backup documentation that supports the cost or resource estimate (e.g. vendor quotes, engineering estimates, etc.) needed to complete each WBS task/element.

5.2 QUALITY ASSURANCE PROGRAM

Quality assurance is an integral part of the design, procurement, fabrication, and construction phases of the U.S. CMS Project. Special attention is being devoted to items that will affect the performance capability and operation of the CMS detectors. The responsible person for technical specifications is the U.S. CMS technical director.

It is the policy of U.S. CMS that all activities shall be performed at a level of quality appropriate to achieving the technical, cost, and schedule objectives of the project. To implement this policy, the U.S. CMS Project will develop quality control systems and methodologies based on the quality assurance criteria established by DOE and NSF, and any necessary quality controls applicable to CERN. The responsible person for the U.S. CMS Quality Assurance Plan is the U.S. CMS Project Manager.

Major U.S. CMS production efforts, such as the EMU Cathode Strip Chambers (CSC's) or the HCAL Megatile Factory, will implement special quality control programs based upon Fermilab's Traveler Program. Travelers consist of hand-written assembly and testing documentation that "travel" with the deliverable during the construction and fabrication process that documents the fabrication process. Traveler quality assurance documentation will be stored within the U.S. CMS Project and will be available for reference if necessary.

Due to the complexities of delivering components for an international scientific project, all major deliverables undergo Engineering Design Reviews (EDR's) prior to placing large procurements or starting major production facilities, which normally include collaboration wide reviewers. Quality assurance and control procedures are carefully reviewed in each EDR to ensure that each major investment to CMS is properly constructed and documented.

Vendors will implement quality assurance programs appropriate to the services being furnished. As specified in the Memorandum of Understanding, U.S. CMS activities at each institution will use the implemented quality assurance programs. All these programs, as well as implementing procedures, are subject to review and audit by the US CMS Project Office at Fermilab.

5.3 ENVIRONMENT, SAFETY, AND HEALTH (ES&H)

Activities conducted at U.S. institutions will adhere to the ES&H policies and procedures of those specific institutions. The annual Statements of Work (SOW) signed between the institution and U.S. CMS identify a responsible safety person for CMS activities at each institution.

Three large activities are taking place at Fermilab: construction of the Endcap Muon CSC's, construction of the Hadron Calorimeter optical scintillating tiles, and construction of the silicon modules for the CMS Silicon Tracker Outer Barrel. The CSC's will follow the ES&H procedures of Fermilab's Technical Division, whereas the HCAL scintillating tiles are being constructed by Fermilab's Particle Physics Division. Regular safety audits are conducted in accordance with each division's normal ES&H practices.

As U.S. deliverables are assembled and installed into the CMS detector at CERN, U.S. CMS design and fabrication activities take into account the appropriate CERN safety specifications, procedures, and guidelines. Furthermore, CERN safety personnel including the CMS Group Leader in Matters of Safety (GLIMOS) and a member of Technical Inspection and Safety (TIS) commission regularly participate in Engineering Design Reviews (EDR's) of those items being provided by U.S. CMS that have important safety ramifications. Appropriate TIS personnel approve the safety aspects of the designs.

6. PROJECT SCHEDULE AND MILESTONES

6.1 BASELINE SCHEDULES

The Work Breakdown Structure (WBS) also supports a systematic approach in preparing the project schedule. Each element at the lowest WBS level of the structure is assigned a duration. It is then linked to related elements, thus establishing the interdependencies between the various elements to create an integrated project schedule for each L2 subsystem. With all tasks for a L2 subsystem linked into a complete integrated project, the L2 critical path is defined at the task level providing management an understanding of the critical elements that directly impact the overall schedule and those that have slack time.

Each L2 WBS provides the approved baseline schedule for its respective subsystem. The baseline schedule is held by the L2 Manager and sets forth the approved major activities, decision points, and activity interfaces essential for completion of each respective subsystem in the U.S. CMS Project.

Through continuous communication with CMS, each L2 integrated project schedule is continually updated to maintain agreement with the latest CMS and LHC global schedules at CERN. Each L2 project schedule is also continually updated to optimize the resources of the U.S. CMS Collaboration by shifting tasks to those groups that are most able to achieve the tasks of each subsystem within the planned schedule and estimated budget.

The L2 WBS is supported by Microsoft Project software, which is used throughout the U.S. CMS Collaboration and the CMS Collaboration.

6.2 BASELINE MILESTONES

The U.S. CMS Project is a subproject of the international CMS Detector Project, which is in itself a subproject of the international LHC Project at CERN. To ensure that the U.S. CMS Project is in agreement with the CMS and the LHC, U.S. CMS has adopted a set of milestones that is a subset of the official CMS milestones. These milestones are consistent with the global LHC milestones, and are updated whenever major rebaselines of the global schedule occur. The official milestones for CMS are arranged in a hierarchy of Level 1, Level 2 and Level 3 milestones, and using an analogous structure, U.S. CMS has adopted a set of Level 1, Level 2

and Level 3 milestones. These milestones are chosen primarily to provide a means of tracking the performance of U.S. CMS deliverables to the CMS detector, but also include key integration milestones with its international partners for coordination and communication purposes.

Currently, there are 246 Level 1, Level 2, and Level 3 milestones tracked to assess the performance of U.S. CMS over the life of the construction project. A subset of U.S. CMS milestones are tracked jointly by the U.S. DOE/NSF Project Manager and Fermilab Deputy Director to address key U.S. production points and delivery of U.S. commitments to CMS. The performance of these milestones, named APM-DD milestones, is regularly reported in the U.S. CMS Monthly Report and at PMG meetings. Finally, agency-level Critical Decision (CD) milestones are also tracked and are reported at the PMG and the quarterly JOG meetings. The APM-DD milestones under change control are shown in Appendix 8.

L2 managers report their milestone performance to the U.S. CMS Project Office on a monthly basis. When necessary to change the date of a controlled milestone, the change is recorded processed according to the Change Control thresholds, given in Appendix 10.

7. PROJECT COST BASELINE ESTIMATES

The Total Project Cost (TPC) of the U.S. CMS Project is \$167.25M AY. When baselined in June 1998, the approved cost baseline for U.S. CMS was \$119.58M AY, which included the FY96-FY97 R&D funds of \$6.92M AY. Contingency funds amounted to \$47.67M AY, or approximately 40% of the baseline cost.

At the end of FY02, the approved cost baseline, Budget At Completion (BAC) for U.S. CMS is \$145.79M AY, with \$21.46M AY contingency. Contingency allocations have been applied primarily to cover cost overruns and to maintain the baseline schedule. As the U.S. CMS Project reported good cost control, some contingency has been allocated to increasing the scope of the U.S. CMS Project. This application of contingency towards scope increases will continue as long as there is continued good cost and schedule performance against the baseline.

Appendix 9 shows the U.S. CMS base costs at WBS Level 2. Included in the baseline cost are the procurement, assembly, and installation of all technical components, engineering design, inspection, and project management required to assure successful completion of the U.S. CMS project. These cost estimates are determined using a 'bottoms-up' approach with the basis for the costs derived at the lowest WBS from the responsible manager.

Continually updating each L2 subsystem cost and schedule baseline is encouraged to ensure that the latest information is captured in each L2 subsystem file. Changes to the baseline costs, technical scope, schedules and overall planning are treated as variances to the baseline. These variances are tracked by the WBS and are approved and documented according to the approved Change Control described in Section 8.

The funding profile for the U.S. CMS Project is shown in Appendix 11. U.S. CMS obligations are planned to saturate available budget in each given year. All funds are in actual-year dollars (AY\$) with assumed rates of out-year escalation shown in Appendix 12. Escalation values are based upon guidance from guidance provided by the DOE Office of Engineering and Construction Management for Energy Research and Nuclear Construction Projects.

8 EARNED VALUE MEASUREMENT AND CHANGE CONTROL

8.1 U.S. CMS EARNED VALUE MEASUREMENT SYSTEM

Budgeted Cost of Work Scheduled (BCWS) is the time-phased budget that represents the dollar value of the work planned over a given period of time. As work is completed, budget associated with this work is “earned”, defined by the Budgeted Cost of Work Performed (BCWP), or earned value. The actual cost of the resources consumed in performing the work is represented by the Actual Cost of Work Performed (ACWP). The difference between BCWP and ACWP is the cost variance (CV). The difference between BCWP and BCWS is the schedule variance (SV) expressed in dollar terms.

For each U.S. CMS L2 subsystem, the current values of the BCWS, BCWP, SV, and CV are reported at the lowest WBS in a Cost Performance Report (CPR). The L2 CPR follows a subsystem’s WBS and can be “rolled-up” to assess the performance for an individual task/element or for major portions of a project or subsystem. The L2 CPR is the main tool in measuring cost and schedule progress and variances, and for tracking actual costs within each U.S. CMS subsystem.

Each Level 2 Manager is responsible for updating progress in their subsystem file by estimating a percent complete for all active WBS tasks/elements. The updated progress on each WBS task/element is then processed by the U.S. CMS Project Office to derive the BCWP. The L2 CPR also contains cumulative data on the actual costs (ACWP) at the lowest WBS task/element, thus providing all the necessary data to compile the L2 CPR.

Each month, the U.S. CMS Project Office provides updated L2 CPR’s for each subsystem to the L2 managers. After reviewing the status of their earned value performance and budget/actuals versus work accomplished to date, L2 managers may need to take corrective actions (i.e., adding resources, rescheduling or descoping work, increasing budgets by requesting contingency, etc.) to keep on an acceptable budget and scheduling path. Changes to the approved baseline are made in close communication with the U.S. CMS Project Manager and are documented according to Change Control Procedures as defined in the following section.

8.2 U.S. CMS CHANGE CONTROL

Each U.S. CMS L2 Manager is responsible for submitting an updated L2 project file for his or her subsystem to the U.S. CMS PO by the tenth day of the following month (i.e. month-

ending August file is due in the PO by September 10th). The responsible manager, typically the L2 manager, should update the percent complete value for each active task/element in the project file to reflect the most recent progress.

The project file can also be amended by the L2 Manager to address any scope, schedule, or cost changes to the baseline plan. When submitted to the U.S. CMS Project Office, the amended project file constitutes a proposed change to the specific L2 baseline.

Low-level changes to the L2 baseline plan (i.e., cost changes below \$25K, no scope changes, minor schedule adjustments) are documented in the PO using the Change Log, with no further documentation required by the L2 Manager. The Change Log compares each WBS task/element of the proposed file to the baseline file and documents the baseline variances. Larger changes, cost changes greater than \$25K, scope changes, or schedule changes that shift U.S. CMS milestones, require a Baseline Change Request (BCR). BCR's are initiated by submitting a revised L2 MS Project file to the U.S. CMS Project Office (PO), but also require a brief statement from the L2 manager summarizing the reason for the changes. The BCR then follows the change approval procedures described in Appendix 10.

The U.S. CMS Project Office at Fermilab will control and document changes in project scope, cost, and schedule, and maintain a traceable record of all BCR's. The U.S. CMS Deputy Project Manager, with support from the U.S. CMS Project Office, is responsible for maintaining and tracking all changes to the current cost, schedule, and scope of the U.S. CMS Project. All changes must be approved at the appropriate level before implementation. Once approved, the changes will be incorporated into the subsystem's WBS, estimated cost, schedule, scope, budget, estimate to complete, etc. as required. BCR's that are not approved require the L2 manager to submit a revised project file, which is then reprocessed in the PO, and compared to the last approved baseline file.

The Project Management Group (PMG), chaired by the Fermilab Deputy Director, acts as a high level Change Control Board for the US CMS Project. The PMG will have as its purview assignment of contingency funds, changes of the scope of the project, and changes to the schedule at the threshold level described in Appendix 10. Scope reductions may be required should projected costs of any Level 2 subsystem greatly exceed the Budget At Completion. The U.S. CMS Project Manager must also refer any change that affects the interaction between

detector subsystems or that significantly affect the performance, schedule, or the safety of the detector to the CMS Steering Committee/Management Board.

9 PROJECT REPORTING, COMMUNICATION AND REVIEW

9.1 U.S. CMS MONTHLY REPORT

The objective of the reporting and review activity is to provide for the collection, integration and transmission of information needed for managing and monitoring the US CMS Project. For this purpose, the U.S. CMS Project Manager will produce a monthly report on the status, progress and issues currently relevant to the U.S. CMS Project. The U.S. CMS Monthly Report will typically contain a narrative describing the technical progress of the U.S. CMS project including international issues, with an “earned-value” section that will quantitatively measure the performance and variances of the U.S. CMS Project. Financial information will be provided for the current month, cumulative to date, and at completion. Contingency will be reported in actual dollars and as a percentage of remaining work. Milestone performance will be reported against the baseline dates. Documenting baseline change requests for the given month will also be included.

The U.S. CMS Monthly Report is the primary form of written communication outside of U.S. CMS. The monthly report is provided to the U.S. DOE/NSF Project Office, the Fermilab Deputy Director, and to DOE and NSF agency officials in Washington D.C.. Internal reports, or targeted issue reports can be prepared at any time or level desired.

9.2 PROJECT COMMUNICATIONS AND REVIEW

The U.S. CMS Project requires the close collaboration between U.S. CMS, CMS, CERN DOE, NSF, and Fermilab. In order to progress successfully, all parties will need to be in regular communication on current progress, plans, issues, problems, solutions, and achievements. To facilitate good communication and coordination within the CMS and U.S. CMS Collaborations, a number of regularly scheduled meetings are conducted, some of which are described below;

- a) CMS Collaboration Meeting (all CMS Collaborators). Quarterly meetings for members of the collaboration to meet and discuss progress on the overall CMS detector, as well as work through integration issues. This collaboration-wide quarterly meeting, also known as ‘CMS Week’, includes meetings of the CMS Collaboration Board, CMS Management

Board, CMS Technical Board, CMS Finance Board, CMS Safety Working Group, and many technical and integration meetings at the subsystem level.

- b) CMS Technical Coordination Meeting (CMS Technical Coordination Group, and CMS Collaborating Institutions). Monthly meetings between U.S. CMS managers and CMS Technical Coordination to discuss technical issues on the construction of the CMS detector.
- c) CMS Resource Review Board Meeting (CMS Management, U.S. CMS PM, U.S. ATLAS PM, U.S. LHC Accelerator PM, DOE/NSF Representatives). Biannual meeting with funding agency representation to review cost and schedule progress on the LHC Project.
- d) CMS Steering Committee Meeting (CMS Management and Level 2 Project Managers). Monthly meetings to supervise and review the technical progress of the CMS detector and to formulate solutions to technical problems.
- e) CMS Engineering Design Reviews/Production Readiness Reviews (CMS management, technical and integration experts from affected subsystems). Reviews, as necessary, to initiate procurements or launch production efforts requiring the endorsement of CMS and subsystem management.
- f) DOE/NSF Office of Science/Construction Management Division (SC/CMD) Review (U.S. CMS Collaboration, and DOE/NSF Management). Bi-annual agency review of the technical, cost, schedule, and scope aspects of the U.S. CMS Project, utilizing technical and management experts external to the project.
- g) DOE/NSF Status Meeting (U.S. CMS Project Office, and DOE/NSF Project Management). Quarterly status meeting (scheduled between the DOE/NSF SC/CMD Review) on the technical, cost, schedule, and scope issues of the U.S. CMS Project.
- h) DOE/NSF Joint Oversight Group Meeting (U.S. CMS PM, U.S. ATLAS PM, U.S. LHC Accelerator PM, JOG Committee) Bi-annual meeting to coordinate all three U.S. LHC Projects.
- i) DOE/NSF Base Program Support Meeting (U.S. CMS PM/DPM, and U.S. Collaboration Chair and Deputy Chair, and DOE/NSF Base Program Management). Annual meeting between the DOE and NSF base program managers and U.S. CMS management.

- j) U.S. CMS Project Manager's Group Meeting (Fermilab Management, U.S. CMS PO, L2 Subsystem Managers, DOE/NSF FAO Managers). Monthly meetings on the technical, cost, schedule and contingency performance of U.S. CMS.
- k) U.S. CMS Level 1 – Level 2 Meeting (U.S. CMS PM/DPM and L2 Subsystem Manager). Monthly or bimonthly meetings to coordinate the efforts of the U.S. CMS Collaboration at the subsystem level.
- l) U.S. CMS Project Office Meeting (Fermilab, Northeastern University and CERN). Weekly or biweekly meeting to coordinate the efforts of the U.S. CMS Collaboration.

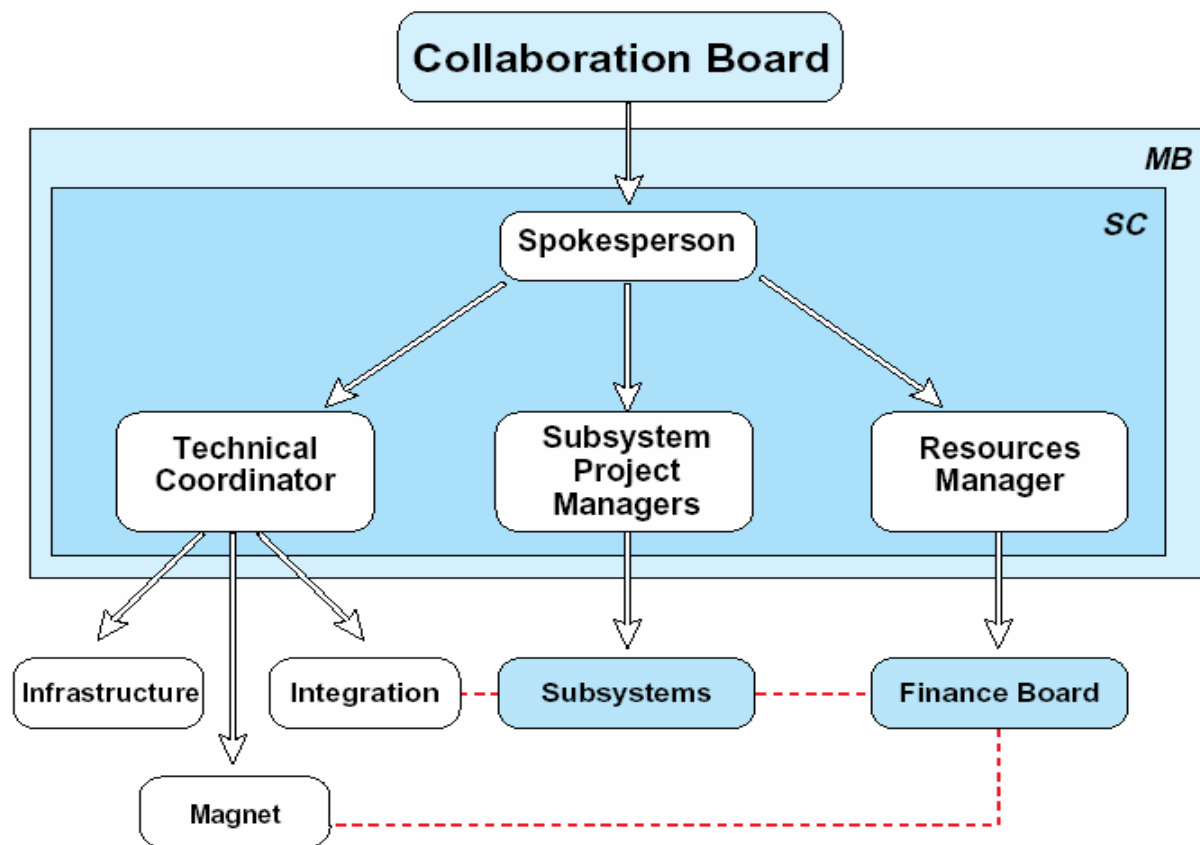
Communication within CMS, U.S. CMS and amongst DOE and NSF management is openly encouraged to provide as transparent an organization as is possible. Notes, "drafts," phone calls, electronic mail, and informal discussions are exchanged frequently among the participants to accomplish information flow, raise issues for mutual resolution, and explore the viability of plans and solutions. Distribution of copies of informal correspondence to all participants is desirable to keep them fully apprised of the most recent developments.

Videoconferencing plays an important role in the transmission of information, as is expected on a project of the size, scope and organizational structure of CMS. The World Wide Web is also proving a valuable tool in providing up to date information to members of the collaboration and others. The web home pages for CMS and US CMS are <http://cmsinfo.cern.ch/Welcome.html> and <http://uscms.fnal.gov>, respectively. Many links exist at these sites to other information sources.

APPENDIX 1: U.S. CMS COLLABORATING INSTITUTIONS

Institution	Agency Support
Boston University	DOE/NSF
University of California at Davis	DOE
University of California at Los Angeles	DOE/NSF
University of California at Riverside	DOE
University of California at San Diego	DOE/NSF
University of California at Santa Barbara	DOE
California Institute of Technology	DOE
Carnegie Mellon University	DOE
Fairfield University	DOE
Fermi National Accelerator Laboratory*	DOE
University of Florida	DOE
Florida Institute of Technology	DOE
Florida International University	NSF
Florida State University	DOE
University of Illinois at Chicago	NSF
University of Iowa	DOE
Iowa State University	DOE
Johns Hopkins University	NSF
University of Kansas	NSF
Kansas State University	DOE
University of Maryland	DOE
Massachusetts Institute of Technology	DOE
University of Minnesota	DOE
University of Mississippi	DOE
University of Nebraska	NSF
Northeastern University	NSF
Northwestern University	DOE
University of Notre Dame	NSF
Ohio State University	DOE
Princeton University	DOE
Purdue University	DOE
Rice University	DOE
Rutgers University	NSF
University of Rochester	DOE
University of Texas at Dallas	DOE
Texas Tech University	DOE
Virginia Technical Institute	NSF
University of Wisconsin at Madison	DOE
University of Yale	DOE

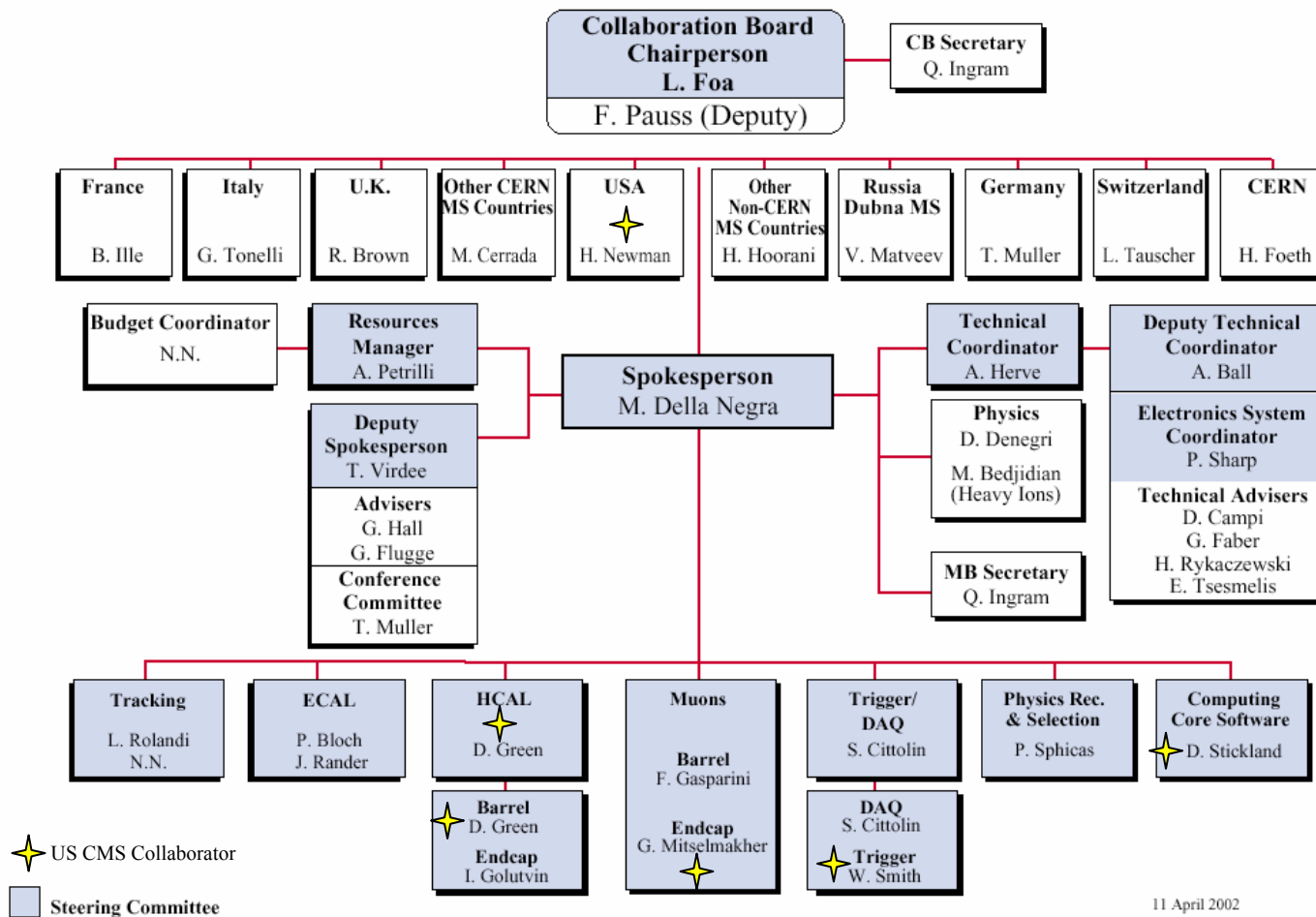
* Designated as Host Laboratory for the U.S. CMS Construction Project

APPENDIX 2: CMS EXECUTIVE HIERARCHY**Hierarchical Relationship between the CMS Federal Bodies**

29 Oct. 1998

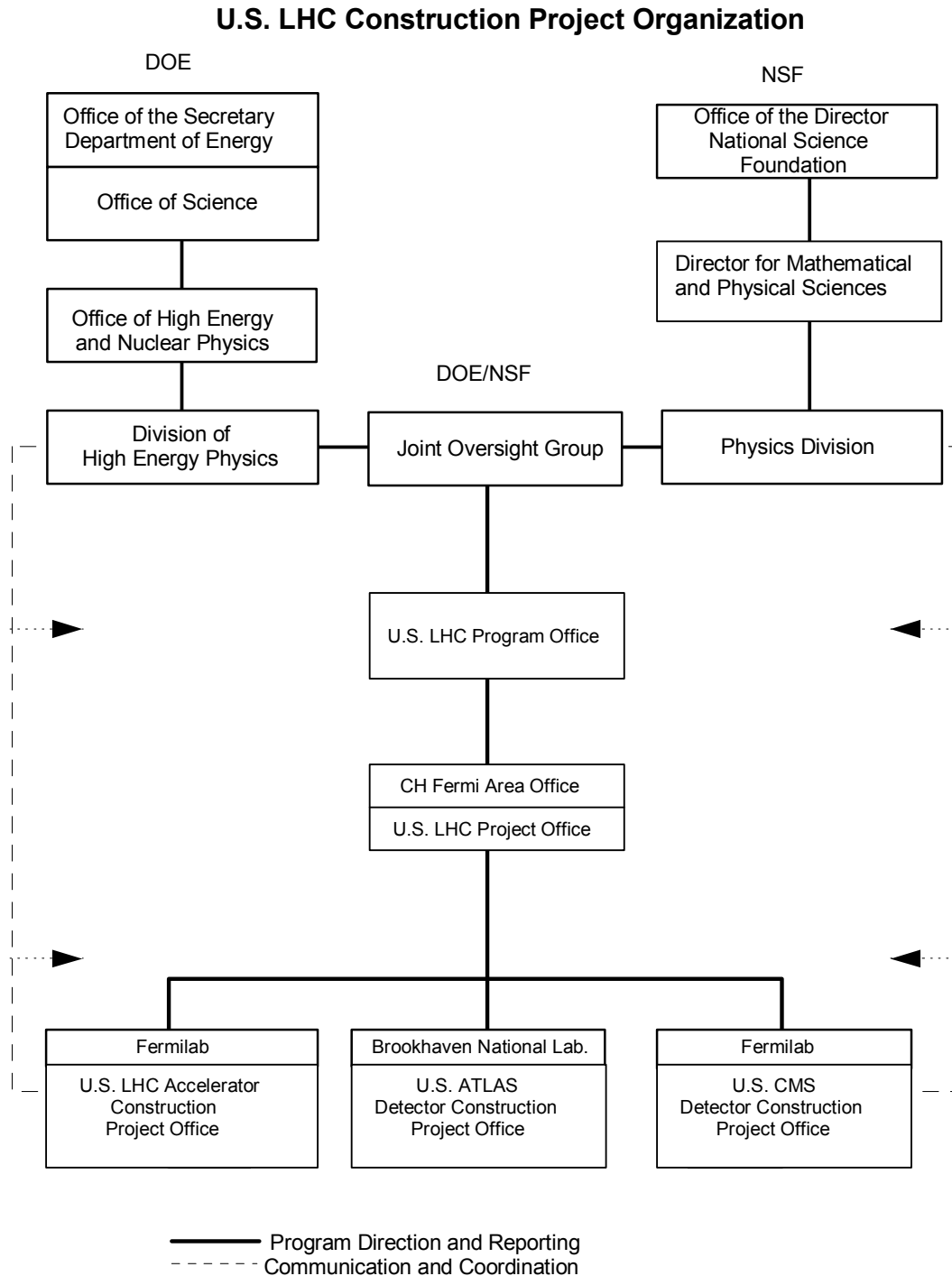
APPENDIX 3: CMS EXECUTIVE ORGANIZATION

CMS Management Board and Steering Committee

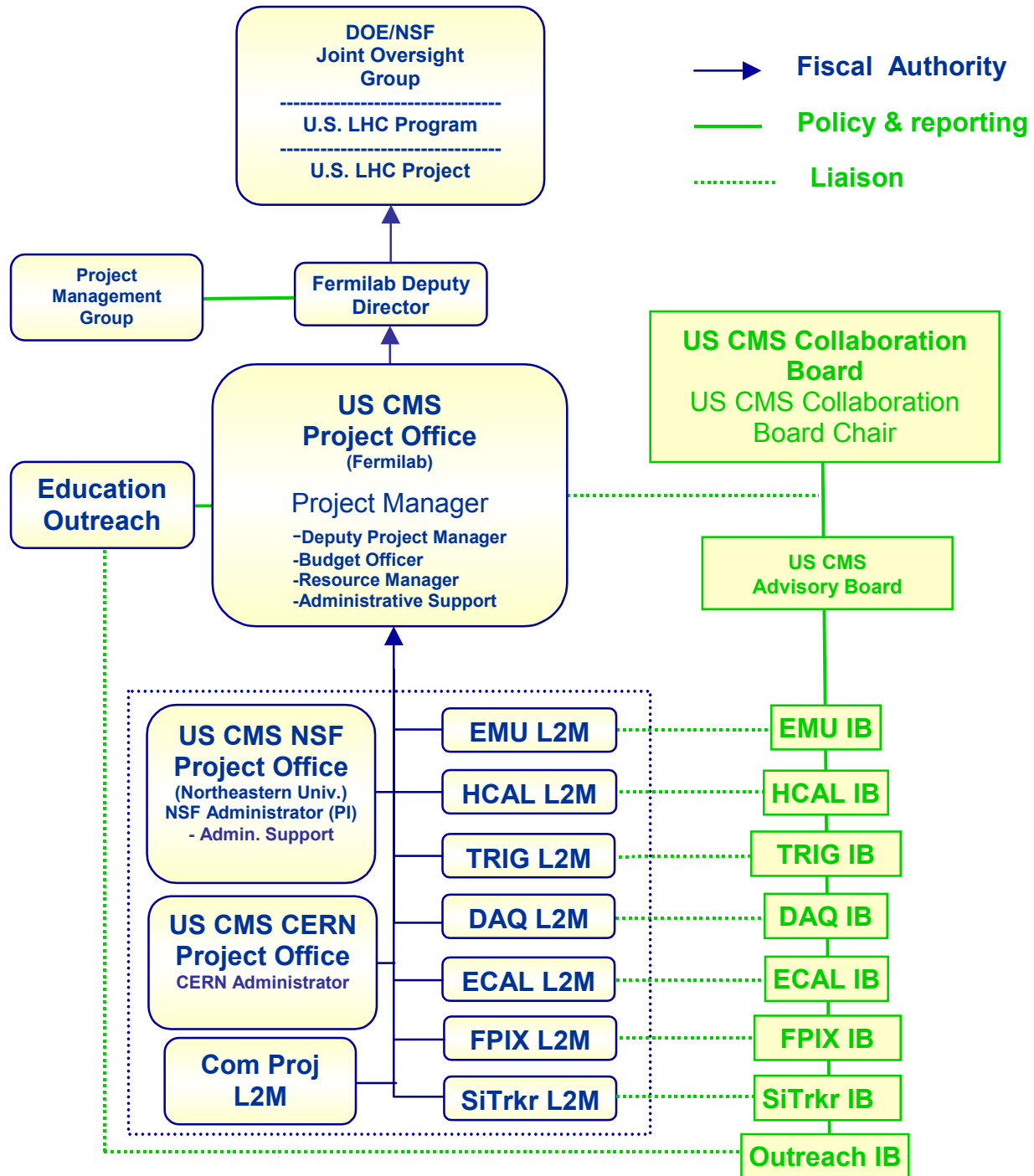


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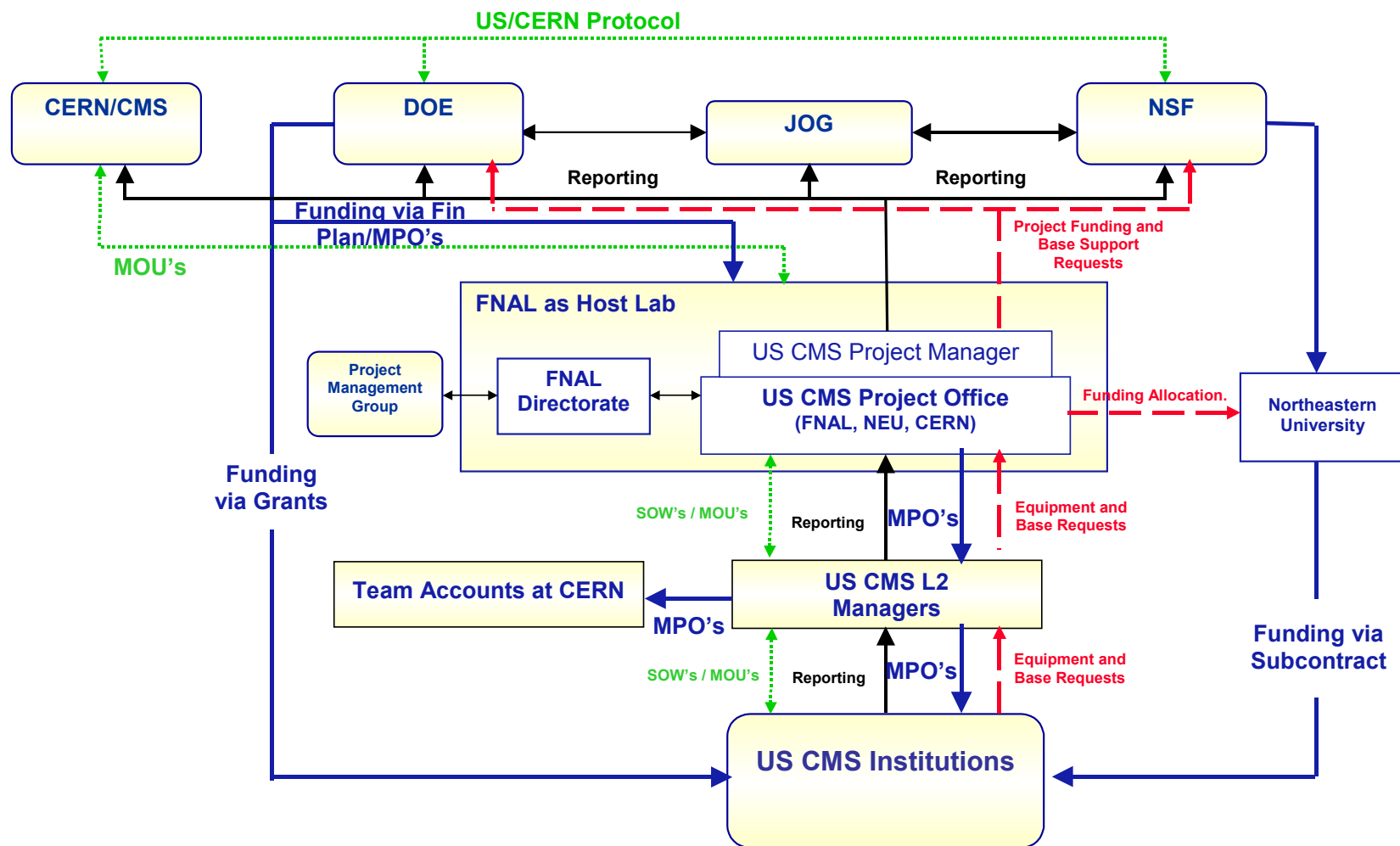
APPENDIX 4: DOE – NSF – U.S. CMS OVERSIGHT FUNCTION



APPENDIX 5: U.S. CMS PROJECT OFFICE ORGANIZATION

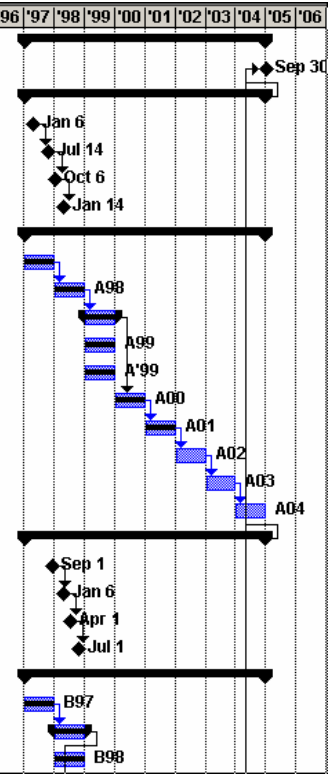


APPENDIX 6: MOU, FUNDING AND REPORTING PROCESS



APPENDIX 7: EXAMPLE OF U.S. CMS L2 WBS (COMMON PROJECTS)

WBS	Name	US Base Cost	Start	Duration	Funding	Institution	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06
6	Common Projects	\$23,000,000.00	Oct 1 '96	2000 days													
CP/US-CP.01	US CMS End of Project	\$0.00	Sep 30 '04	0 days													
6.1	Pack A, Barrel Yoke and Vac Tank	\$7,923,832.00	Oct 1 '96	2000 days		Fermilab											
6.1.1	market survey complete (RFI)	\$0.00	Jan 6 '97	0 days													
6.1.2	call for tenders (RFQ)	\$0.00	Jul 14 '97	0 days													
6.1.3	open bids	\$0.00	Oct 6 '97	0 days													
6.1.4	award contract	\$0.00	Jan 14 '98	0 days													
6.1.5	package payments	\$7,923,832.00	Oct 1 '96	2000 days													
6.1.5.1	Y97	\$0.00	Oct 1 '96	250 days	DOE	Fermilab											
6.1.5.2	Y98	\$2,791,175.00	Oct 1 '97	249 days	DOE	Fermilab											
6.1.5.3	Y99	\$5,132,657.00	Oct 1 '98	250 days		Fermilab											
6.1.5.3.1	Y99 - DOE	\$2,938,657.00	Oct 1 '98	249 days	DOE	Fermilab											
6.1.5.3.2	Y99 - NSF	\$2,194,000.00	Oct 1 '98	250 days	NSF	NEU											
6.1.5.4	Y00	\$0.00	Oct 1 '99	250 days	DOE	Fermilab											
6.1.5.5	Y01	\$0.00	Oct 2 '00	250 days	DOE	Fermilab											
6.1.5.6	Y02	\$0.00	Oct 1 '01	250 days	DOE	Fermilab											
6.1.5.7	Y03	\$0.00	Oct 1 '02	250 days	DOE	Fermilab											
6.1.5.8	Y04	\$0.00	Oct 1 '03	250 days	DOE	Fermilab											
6.2	Pack B, Endcap Yoke	\$9,063,700.00	Oct 1 '96	2000 days		Wisconsin											
6.2.1	market survey complete (RFI)	\$0.00	Sep 1 '97	0 days													
6.2.2	call for tenders (RFQ)	\$0.00	Jan 6 '98	0 days													
6.2.3	open bids	\$0.00	Apr 1 '98	0 days													
6.2.4	award contract	\$0.00	Jul 1 '98	0 days													
6.2.5	package payments	\$9,063,700.00	Oct 1 '96	2000 days													
6.2.5.1	Y97	\$0.00	Oct 1 '96	249 days	DOE	Wisconsin											
6.2.5.2	Y98	\$1,307,500.00	Oct 1 '97	250 days													
6.2.5.2.1	MPO	\$1,007,500.00	Oct 1 '97	250 days	DOE	Wisconsin											



APPENDIX 8: U.S. CMS MILESTONES UNDER CHANGE CONTROL (JOG AND APM-DD MILESTONES)

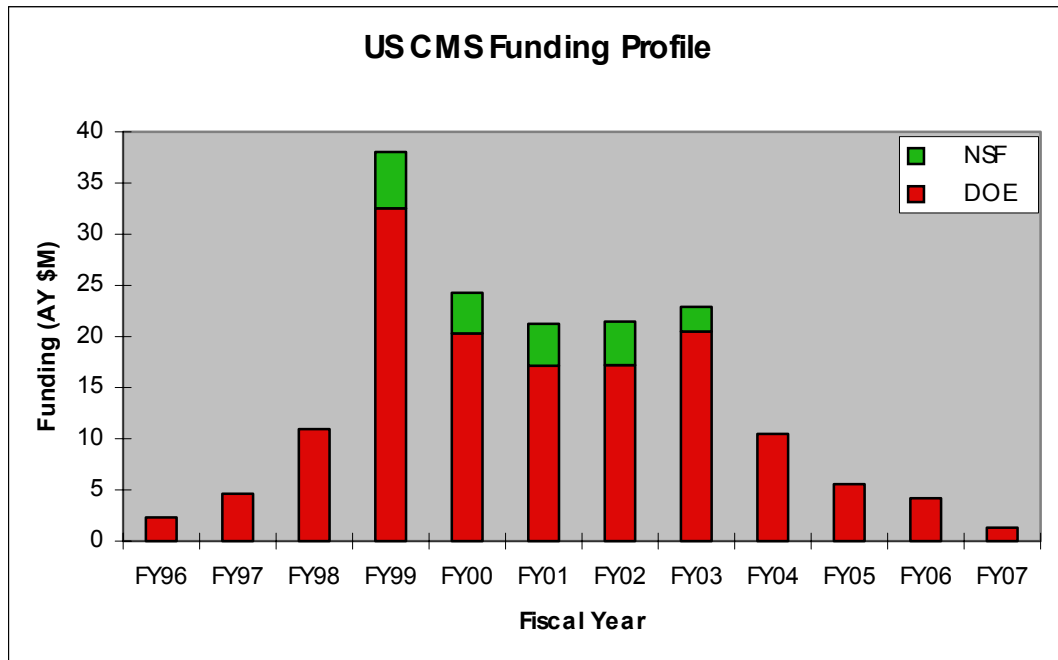
	<i>JOG * Milestone</i>	<i>Baseline</i>	<i>Status</i>	<i>US CMS ID</i>	<i>APM/DD ** Milestone</i>	<i>Baseline</i>	<i>Status</i>
1	DOE/NSF CERN Agreement	1-Dec-97	Complete	HCAL/HB-024	HB: Start Optics Production	31-Jan-99	Complete
2	Approve Baseline	1-Jul-98	Complete	MUON/ME-011	Begin Assembly of Cathode Strip Chambers at FNAL	14-Jul-00	Complete
3	Approve Project Management Plan	1-Sep-98	Complete	HCAL/HB-026	HB-1 Optical Assemblies 100% Complete	15-Sep-00	Complete
4	US CMS Project Complete (CD-4A)	30-Sep-05	30-Sep-05	HCAL/HB-010	HB-1 Absorber Delivered to CERN	30-Nov-00	Complete
5	US CMS Project Complete (CD-4B)	30-Sep-08	30-Sep-08	MUON/ME-013	Begin Mass Production of Electronics Boards	31-Mar-01	Complete
6				HCAL/HB-014	HB+1 Absorber Delivered to CERN	30-Sep-01	Complete
7				HCAL/HB-016	HB-1 End Module Assembly in SX5	30-Oct-01	Complete
8				SiTrkr/TS-027	Begin Sensor Module Construction (for M200)	31-Oct-01	Complete
9				HCAL/HG-039	HF: Start PMT Procurement	30-Nov-01	Complete
10				HCAL/HG-1004	Start HPD Procurement	30-Nov-01	Complete
11				MUON/ME-014	Begin Mounting Electronics and Testing at UCLA/UF	6-Dec-01	Complete
12				CP/SY-059	End Assembly of YE+3	10-Dec-01	Complete
13				HCAL/HB-029	HB+1 Optical Assemblies 100% Complete	31-Dec-01	Complete
14				HCAL/HG-1009	HF: PMT Tests 100% Complete	1-Oct-02	1-Oct-02
15				HCAL/HG-1012	QIE ASIC Production Run Complete	31-Dec-02	31-Dec-02
16				HCAL/HB-017	End Assembly of HB+ (Barrel) in SX5	15-Jan-03	15-Jan-03
17				MUON/ME-061	70 ME23/2 CSC's Delivered from UC/UF to CERN	31-Mar-03	31-Mar-03
18				HCAL/HG-002	HCAL Front-End Electronics Production Complete	31-Mar-03	31-Mar-03
19				ECAL/4.3.8.11m	All Lasers (3) Delivered & Installed at CERN	30-Jun-03	30-Jun-03
20				HCAL/HG-1016	HCAL HPD Tests 100% Complete	29-Aug-03	29-Aug-03
21				ECAL/EB-027	EB Front-End Electronics Production Launched	15-Oct-03	15-Oct-03
22				SiTrkr/TS-1070	25% of Rods Complete	30-Nov-03	30-Nov-03
23				MUON/ME-017	All 148 ME23/2 CSC's Delivered from UC/UF to CERN	31-Jan-04	31-Jan-04
24				SiTrkr/TS-1073	50% of Rods Completed	31-Mar-04	31-Mar-04
25				ECAL/EB-045	All APDs Delivered	14-May-04	14-May-04
26				FPIX/TP-1002	Final Full Size ROC Submission (0.25micron)	31-May-04	31-May-04
27				DAQ/QR-1014	Start of Readout and EVB Commissioning	31-Jul-04	31-Jul-04
28				CP/US-CP.01	US CMS Common Project Commitment Complete	30-Sep-04	30-Sep-04
29				ECAL/4.6.1.8m	FPPA Delivery Complete	1-Oct-04	1-Oct-04
30				ECAL/4.6.3.9m	Optical Link Delivery Complete	1-Oct-04	1-Oct-04
31				HCAL/HG-1018	HCAL "Slice" Test II in SX5 Complete	30-Nov-04	30-Nov-04
32				TRIG/QT-1350	CSC: Muon Port Card Production Test Complete	30-Nov-04	30-Nov-04
33				ECAL/EB-046	ECAL Front-End Electronics Production Complete	15-Dec-04	15-Dec-04
34				SiTrkr/TS-XXX	TOB Complete	15-Apr-05	15-Apr-05
35				CP/TA-1010	UX Ready (Start Lowering Magnet Parts)	30-Apr-05	30-Apr-05
36				PO/US-PO.01	US CMS Project Office Construction Support Complete	30-Sep-05	30-Sep-05
37				TRIG/QT-1008	Finish Trigger Installation	30-Nov-05	30-Nov-05
38				HCAL/HB-023	End Cabling and Test of HB in UX5	30-Dec-05	30-Dec-05
39				DAQ/QR-1023	DAQ.0: 25% Performance Installed	31-Jan-06	31-Jan-06
40				FPIX/TP-1015	First Butterfly Ready	15-Mar-06	15-Mar-06
41				HCAL/HE-015	End Cabling and Test of HE-1 in UX5	30-Jun-06	30-Jun-06
42				ECAL/EG-019	End Inst., Test, & Debug. of EB (barrel) in UX5	30-Jun-06	30-Jun-06
43				SiTrkr/TG-014	End Installation and Cabling of SiTrkr in UX5	30-Jun-06	30-Jun-06
44				MUON/ME-1083	End UX inst/cabling/test of CSC stations on YE-	31-Jul-06	31-Jul-06
45				HCAL/HF-025	HF: Installation and Testing in UX5 Complete	9-Nov-06	9-Nov-06
46				FPIX/TP-1004	Pixel Tracker at SX5, Ready for Installation	30-Mar-07	30-Mar-07

APPENDIX 9: US CMS COST BASELINE (30 SEPTEMBER 2002)

U.S. CMS Construction Project		
WBS	L2 Subsystem	Budget-at-Completion (AYK\$)
1	Endcap Muon	\$39,259
2	Hadron Calorimeter	\$41,077
3	Trigger and Data Acquisition	\$12,408
4	Electromagnetic Calorimeter	\$12,663
5	Forward Pixels	\$7,268
6	Common Projects	\$23,000
7	Project Office	\$6,794
8	Silicon Tracker	\$3,323
Subtotal		\$145,792
Contingency		\$21,458
Total Project Cost		\$167,250

APPENDIX 10: U.S. CMS PROJECT MANAGEMENT CHANGE CONTROL THRESHOLDS

	Level 0	Level 1	Level 2	Level 3	Level 4
	DOE Director of Science	DOE/NSF Joint Oversight Group	DOE/NSF LHC Project Manager	Fermilab Deputy Director	US CMS Project Manager / Deputy Proj Manager
	NSF Director of Math. & Physical Sciences				
Technical	Changes that require modification to the US/CERN Agreement and Experiments Protocol	Significant changes to the technical baseline [See Reference 10].	Significant changes to the technical baseline [See Reference 10].	Any increase or decrease in scope or physics performance of a subdetector, including tradeoffs among subdetectors.	Any increase or decrease in scope or physics performance of a subdetector, including tradeoffs among subdetectors.
					Changes in scope or detailed design of subdetectors as documented in the CMS Subsystem TDR's.
Schedule	Changes that require modification to the US/CERN Agreement and Experiments Protocol.	Any change greater than six months in a JOG milestone [See Appendix 8].	Greater than three month change in a APM/DD milestone from its baseline date. [See Appendix 8]	Greater than three month change in a APM/DD milestone from its baseline date [See Appendix 8].	Greater than one month change in a APM/DD milestone from its baseline date [See Appendix 8].
			Greater than three month change in any US CMS L1 or L2 milestones.	Greater than three month change in any US CMS L1 or L2 milestones	Greater than one month change to any U.S. CMS L1, L2, or L3 milestones.
Cost	Changes that require modification to the US/CERN Agreement and Experiments Protocol.	Any change to the US CMS Total Project Cost (TPC).	Any increase in the US CMS baseline cost greater than \$1.0 million at WBS Level 2 [See Appendix 5].	Any increase in the US CMS baseline cost greater than \$100 thousand at WBS Level 2 [See Appendix 5].	Any increase or decrease in the US CMS cost baseline up to \$100 thousand at WBS Level 2 [See Appendix 5].

APPENDIX 11: U.S. CMS FUNDING PROFILE (AYM\$) (30 SEPTEMBER 2002)

	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	Total
DOE	2.30	4.62	10.95	32.51	20.30	17.15	17.19	20.48	10.48	5.56	4.20	1.30	147.05
NSF				5.52	3.96	4.07	4.25	2.40					20.20

APPENDIX 12: ASSUMED ESCALATION RATES

Fiscal Year	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07
Escalation Index (Jan'02)	1.025	1.021	1.020	1.016	1.024	1.025	1.026	1.021	1.025	1.029	1.028	1.026
Escalation Factor	0.979	1.000	1.020	1.036	1.000	1.025	1.052	1.074	1.101	1.132	1.164	1.194

*Guidance provided by the DOE's Office of Engineering and Construction Management for Energy Research and Nuclear Construction Projects.

GLOSSARY

ACWP (Actual Cost of Work Performed). Actual cost (in \$) reported through the U.S. CMS cost accounting system up to the present date for a specific WBS#, subproject, or project. This number is not derived, nor an estimate, but contains the actual costs incurred to date.

ATLAS (A Toroidal LH C Apparatus) – A general-purpose particle detector to be installed at Point 1 of the LHC ring. Distinctive features of ATLAS are a large volume, air-core toroidal magnet providing good momentum resolution and sign discrimination for muons and a fine-grained liquid argon electromagnetic calorimeter.

AY\$ (Actual Year Dollars). Dollars in the year spent. Allows the project to estimate out year expenditures while considering escalation estimates. The U.S. CMS project uses the inflation estimates for energy research projects as recommended by the DOE.

BA (Budget Authority). Cumulative funds currently allocated and authorized by the Department of Energy and the National Science Foundation that may be committed and spent by US CMS institutions for project-related activities.

BAC (Budget at Completion). The total estimated cost (in \$) of the project at completion for a given subproject, or project. This is the budgeted cost of the project and does not include any actual costs or the contingency estimates.

BCWP (Budgeted Cost of Work Performed). A measure (in \$) of the amount of planned work for a specific WBS#, subproject, or project that has been physically accomplished up to the present date. This number is based upon the % complete for each active task in a subsystem project file.

BCWS (Budgeted Cost of Work Scheduled). A measure (in \$) of the amount of scheduled work in the project up to the present date for a specific WBS#, subproject, or project. This number is derived from the estimated cost of the planned work to date in a subsystem project file.

CERN (European Organization for Nuclear Research) – An intergovernmental organization established by Convention signed in Paris on 1 July 1953, revised on 17 January 1971. Also known as the European Organization of Particle Physics.

CERN Team Account – An accounts receivable service contract between an U.S. institution and CERN used to purchase goods and services at CERN.

CMS (Compact Muon Solenoid) – A general-purpose particle detector to be installed at Point 5 of the LHC ring. A distinctive feature of CMS is a high field solenoid surrounding a precision tracker providing high precision spatial information for decay vertices and particle tracking.

Contingency (TPC-BAC). The difference (in \$) between the total cost of the project (TPC) and the total base cost of the project (BAC). For US CMS, contingency funds are maintained at L1 in the US CMS Project Office.

Contingency % ((TPC-BAC)/ETC). A measure (in %) between total funding above the budget at completion (contingency), and the amount of work not yet accomplished (ETC). US CMS attempts to hold contingency % at ~50% over the life of the project.

CPI % (Cost Performance Index) = ACWP/BCWP. A measure (in %) of the Actual Cost of Work Performed (actual invoices) versus the Budgeted Cost of Work Performed (% complete estimate). Values greater than 1.0 represents a ‘cost overrun’ condition, and values less than 1.0 represent a ‘cost under run’ condition.

CV (Cost Variance) = BCWP – ACWP. The difference (in \$) between the estimated value of work performed and the actual cost expended for a specific WBS#, subproject, or project. A large positive number may indicate that the work is not being invoiced in a timely manner. A large negative number may indicate that the cost is overrun or will likely overrun in the future.

ETC (Estimate to Complete). BAC-BCWP. This is the difference (in \$) between the total budgeted cost of the project (BAC), and the work already accomplished (BCWP). In other words, it is the work not yet completed on the project.

Host Laboratory – A designated DOE laboratory that has management oversight responsibilities for U.S. LHC Accelerator, U.S. ATLAS, or U.S. CMS activities.

JOG (DOE/NSF Joint Oversight Group) – The combined DOE/NSF operating group for the U.S. LHC Program. The Director of the DOE Division of High Energy Physics and the Director of the NSF Division of Physics serve as co-chairs of the JOG.

LHC (Large Hadron Collider) – A particle accelerator at CERN that will collide two counter-rotating beams of protons, each with energy of up to 7 trillion electron volts (TeV). The beams will collide at four intersection points at which appropriate particle detectors will be located. The accelerator will be fed by an existing cascade of lower-energy accelerators.

LHC Project – The activities by CERN to build the LHC accelerator and to contribute to the construction of, and to provide co-ordination and support for, the LHC experiments. (International Agreement, Article I, 1.5)

Project Complete – U.S. CMS Project Complete, scheduled for September 30, 2008, is broadly defined when all U.S. deliverables are installed with power, signal, and calibration cabling connected in their final location. Due to the international nature of CMS, the U.S. effort is inevitably coupled to its international partners, particularly during the installation phase of detector construction. The LHC schedule requires a two-phased closeout of the U.S. CMS Project, with the first phase (CD-4A) closing out ~97% of the U.S. CMS Project on September 30, 2005, and a second phase (CD-4B) to closeout the U.S. tasks that are directly tied to the LHC schedule on September 30, 2008.

Project Completed % = BCWP/EAC. A measure (in %) of the amount of Budgeted Cost of Work Performed versus the total Estimate at Completion. This is a percentage estimate of how much of the total project is physically completed at any time.

RRB (Resource Review Board) – An oversight board, with representatives of the concerned funding agencies and the CERN management, for each of the LHC detectors, ATLAS, CMS, which reviews and allocates resources required for the project to proceed on cost and schedule. The Co-Chairs of the U.S. DOE/NSF JOG are ex-officio members of the RRB.

SOW (Statement of Work). A non-binding annual agreement between a US CMS collaborating institution and the US CMS Project that describes the amount of work, along with related costs and resources needed to achieve the work, which that institution is responsible for in any given fiscal year.

SPI % (Schedule Performance Index) = BCWP/BCWS. A measure (in %) of the Budgeted Cost of Work Performed versus the Budgeted Cost of Work Scheduled for any given WBS#, subproject, or project.

SV (Schedule Variance) = BCWP - BCWS. The difference (in \$) between the value of physical work performed (BCWP) and the value of the work planned (BCWS) for any WBS#, subproject, or project.

SV % (Schedule Variance %) = (BCWP-BCWS)/BCWS = SPI – 1. A measure (in %) of the Budgeted Cost of Work Performed minus the Budgeted Cost of Work Scheduled, divided by the Budgeted Cost of Work Scheduled.

TPC (Total Project Cost). This is the total cost (in \$) of the project (or subproject). This includes the base cost estimate (EAC) and the contingency estimate. For US CMS, the TPC = 167.25M AY\$.

Upgrade – Improvement or optimization in the capability or function of a detector or accelerator component, subsystem or system intended to enhance its physics productivity.

U.S. LHC Construction Project – U.S. participation in the construction of the LHC accelerator and in the design and fabrication of the ATLAS and CMS detectors. Funding in the amount of \$450M has been provided in the DOE budget plan and \$81M in the NSF budget plan. Details of the U.S. "deliverables" are found in the respective Project Management Plans.

U.S. LHC Program – U.S. participation in construction of the LHC Accelerator and construction and operation at CERN of the ATLAS and CMS detectors. The U.S. LHC Program has two components, the U.S. LHC Construction Project and the U.S. LHC Research Program.

U.S. LHC Research Program – U.S. participation in the operation of the LHC detectors and in the physics investigations enabled by the detectors, following completion of the facility and commissioning of the detectors.

WBS (Work Breakdown Structure) – A method of hierarchically numbering tasks in a traditional outline numbering format. The WBS is used in US CMS to track all resources, schedules, and costs. A WBS# is one of the outline numbers that is used in the subproject for tracking.